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ASSOCIATION D'OCÉANOGRAPHIE PHYSIQUE

Union Géodésique et Géophysique Internationale

FISHERIES
BIOLOGICAL SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS
JUN 8 1951

# PROCES-VERBAUX Nº 5

## GENERAL ASSEMBLY

at

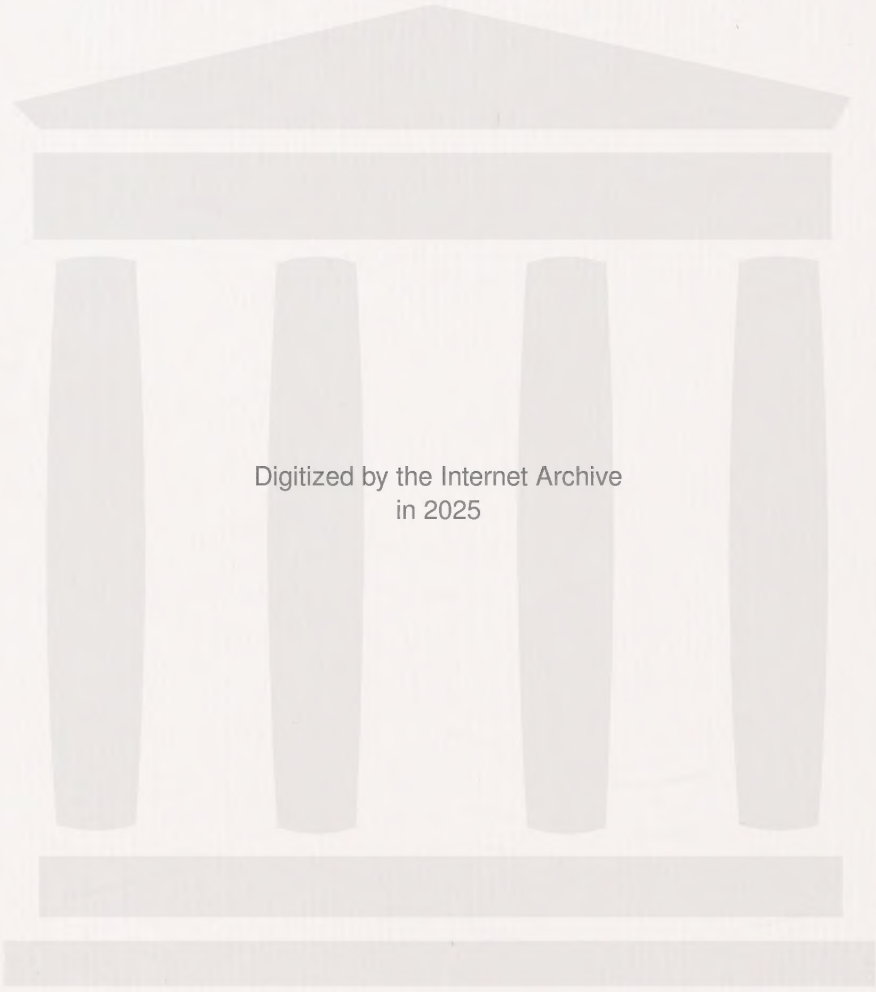
## BRUSSELS

August 1951

Published with financial assistance from UNESCO

1952

Secrétariat de l'Association: Geofysisk Institutt, Bergen, Norway



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ASSOCIATION D'OCEANOGRAPHIE PHYSIQUE

Union Géodésique et Géophysique Internationale

# PROCES-VERBAUX No 5

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*Printed in Norway*

A.S JOHN GRIEGS BOKTRYKKERI

BERGEN

The General Assembly of the
Association was held on the occasion
of the Ninth General Assembly of the Union.
The meetings of the Association were held in the
rooms of the University of Brussels from the
21st to the 30th August 1951

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The Association issues two series of publications, viz. "Publications Scientifiques" and "Procès-Verbaux".

The following numbers have already appeared:

PUBLICATIONS SCIENTIFIQUES.

No. 1. S. F. GRACE:
- I. Historical review of dynamical explanations of tides in non-elongated enclosed seas and lakes.
- II. Historical review of dynamical explanations of the tides of the Mediterranean, the Baltic Sea, the Gulf of Mexico, and the Arctic Ocean (1931).

No. 2. Tidal Bibliography (Third instalment). (1932).

No. 3. Bibliography on tides and certain kindred matters (Fourth instalment). (1936).

No. 4. PHIL E. CHURCH: Temperatures of the Western North Atlantic from thermograph records. (1937).

No. 5. Monthly and annual mean heights of sea-level, up to and including the year 1936. (1940).

No. 6. Bibliography on tides and certain kindred matters (Fifth instalment). (1939).

No. 7. J. P. JACOBSEN and MARTIN KNUDSEN: Urnormal 1937 or Primary Standard sea-water 1937. (1940).

No. 8. Report of the committee on the criteria and nomenclature of the major divisions of the ocean bottom. (1940).

No. 9. B. HELLAND-HANSEN, J. P. JACOBSEN and T. G. THOMPSON: Chemical methods and units. (1948).

No. 10. Monthly and annual mean heights of sea-level, 1937 to 1946 and unpublished data for earlier years. (1950).

No. 11. J. P. JACOBSEN † and REX J. ROBINSON and THOMAS G. THOMPSON: A review of the determination of dissolved oxygen in sea water by the Winkler Method. (1950).

Procès-Verbaux.

No. 1. Cinquième Assemblée Générale réunie à Lisbonne Septembre 1933. (1934).
No. 2. General Assembly at Edinburgh, September 1936. (1937).
No. 3. General Assembly at Washington, September 1939. (1940).
No. 4. General Assembly at Oslo, August 1948. (1949).

These publications form a continuation of the "Bulletins de la Section d'Océanographie de l'Union Géodésique et Géophysique Internationale", of which there were 17 numbers, No. 1 being issued in 1921 and No. 17 in 1931.

# Officers and Executive Committee

(1948—1951)

| | |
|---|---|
| ***President:*** | Professor H. U. SVERDRUP, Norsk Polarinstitutt, Oslo, Norway. |
| ***Vice-Presidents:*** | (1) Professor J. PROUDMAN, The University, Liverpool, England. |
| | (2) Dr. C. O'D. ISELIN, Woods Hole Oceanographic Institution, Mass., U.S.A. |
| ***Secretary:*** | Professor H. MOSBY, Geofysisk Institutt, Bergen, Norway. |
| ***Deputy Secretary:*** | Dr. R. H. FLEMING, Hydrographic Office, U.S. Navy, Washington, D.C., U.S.A. |

***Members:***

Dr. J. N. CARRUTHERS, Great Britain.
Professor H. PETTERSSON, Sweden.
Captain J. ROUCH, France.
Vice-Admiral J. W. TERMIJTELEN, Netherlands.

# Standard Sea-Water Service

(1948—1951)

In charge: 1948 Professor M. KNUDSEN, Charlottenlund slot, Copenhagen.
1949—1951 Mr. H. THOMSEN, Charlottenlund slot, Copenhagen.

# Scientific Committees
(1948—1951)

## Committee on Tides

*Chairman:* H. A. Marmer.
*Secretary:* J. Proudman.
*Members:* J. E. Fjeldstad, A. Gougenheim, W. Horn, N. Menendez, M. Tenani.

## Committee on Mean Sea-Level and its Variations

*Chairman:* J. D. Nares.
*Secretary:* R. H. Corkan.

## Committee on Nomenclature of Ocean Bottom Features

*Chairman:* J. D. H. Wiseman.
*Secretary:* J. D. Nares.
*Members:* K. O. Emery, H. H. Hess, Ph. H. Kuenen, H. Pettersson.

## Committee on Oceanographical Observations from Atlantic Weather Ships

*Chairman:* R. H. Fleming.
*Secretary:* H. Mosby.
*Members:* J. le Gall, J. R. Lumby, F. S. Russell, J. W. Termijtelen, H. Thomsen.

## Committee on Preparation of Technical Handbook on Physical Oceanography

*Chairman:* H. U. Sverdrup.
*Members:* J. N. Carruthers, G. E. R. Deacon, E. C. LaFond, H. Mosby, N. W. Rakestraw.

## Committee on Questions concerning Preparation of a Bibliography

*Chairman:* H. U. SVERDRUP.
*Secretary:* P. GROEN.
*Members:* H. L. G. BENCKER, J. N. CARRUTHERS, L. FAGE, J. R. LUMBY, R. B. MONTGOMERY, R. REVELLE, J. T. RUUD, F. VERCELLI.

# Officers and Executive Committee

Appointed by General Assembly at Brussels, August 1951

***President:*** Prof. Dr. J. PROUDMAN The University, Liverpool, England.

***Vice-Presidents:*** 1) Dr. C. O'D. ISELIN, Woods Hole Oceanographic Institution, Mass., U.S.A.
2) Capitaine J. ROUCH, Musée Océanographique, Monaco.

***Secretary:*** Prof. Dr. H. MOSBY, Geofysisk Institutt, Bergen, Norway.

***Deputy Secretary:*** Dr. R. H. FLEMING, University of Washington, Seattle 5, Wash., U.S.A.

***Members:***

Dr. J. N. CARRUTHERS, Great Britain.
Prof. Dr. H. PETTERSSON, Sweden.
Prof. Dr. P. GROEN, Netherlands.
Prof. Dr. H. U. SVERDRUP, Norway.

# Standard Sea-Water Service

(1951—54)

*In charge:* Mr. H. THOMSEN, Charlottenlund slot, Copenhagen.

# Scientific Committees

Appointed by General Assembly at Brussels, August 1951

## Committee on Tides

*Chairman:* H. A. Marmer.
*Secretary:* J. Proudman.
*Members:* J. E. Fjeldstad, A. Gougenheim, W. Horn, N. Menendez, M. Tenani.

## Committee on Mean Sea-Level and its Variations

*Chairman:* J. D. Nares.
*Secretary:* R. H. Corkan.
*Members:* L. P. Disney, J. Egedal.

## Committee on Nomenclature of Ocean Bottom Features

*Chairman:* J. D. H. Wiseman.
*Secretary:* J. D. Nares.
*Members:* K. O. Emery, H. H. Hess, Ph. H. Kuenen, H. Pettersson.

## Committee on Oceanographical Observations from Atlantic Weather Ships

*Chairman:* J. R. Lumby.
*Secretary:* H. Mosby.
*Members:* J. le Gall, J. Lyman, H. Thomsen, F. S. Russel, J. W. Termijtelen.

## Committee on Preparation of Technical Handbook on Physical Oceanography

*Chairman:* H. U. Sverdrup.
*Members:* J. N. Carruthers, G. E. R. Deacon, E. C. LaFond, H. Mosby, N. W. Rakestraw.

## Committee on Questions concerning Preparation of a Bibliography

*Chairman:* H. U. Sverdrup.
*Secretary:* P. Groen.
*Members:* H. L. G. Bencker, J. N. Carruthers, L. Fage, J. R. Lumby, R. B. Montgomery, R. Revelle, J. T. Ruud, F. Vercelli.

## Terms of Reference of Scientific Committees

*Committee on Tides:* To prepare a bibliography of publications issued up to the end of year 1939.

*Committee on Mean Sea-Level and its Variations:* To collect and publish monthly and yearly mean values of heights of sea-level.

*Committee on Nomenclature of Ocean Bottom Features:* To endeavour to establish, in co-operation with chart-making authorities, mechanisms for international agreement on the nomenclature of submarine topographical features. To consider methods for presentation of marine topographical data on bathymetric charts.

*Committee on Oceanographical Observations from Atlantic Weather Ships:* To encourage each country to undertake systematic physical, chemical, geological and biological observations as their individual facilities and personnel permit. Liaison with the national committees, gradual development of a uniform programme and arrangements for the exchange and for publication of data.

*Committee on Preparation of Technical Handbook on Physical Oceanography:* To prepare a Handbook dealing with installations on board ships, instruments, work at sea, processing of observations and definition of special oceanographic terms.

*Committee on Questions concerning Preparation of a Bibliography:* To present proposals for an international classification of oceanographic literature and to examine the possibility of establishing an international abstract journal.

# Joint Commission on Oceanography

Joint Commissions are set up by the International Council of Scientific Unions (ICSU) to study specific subjects in the borderline fields not adequately covered by any one Union. The International Union of Geodesy and Geophysics (IUGG) is "mother Union" to the Joint Commission on Oceanography (JCO), the International Union of Biological Sciences (IUBS) being the other Union concerned.

At its meeting at Brussels on 30th August 1951 the JCO was radically reorganized, both as regards membership and purpose. The programme of work of the Commission was restricted to *investigations of the deep-sea floor* as follows:

— The morphology and stratigraphy of the deep-sea floor,
— The general properties of the sediment carpet and its substratum,
— The properties of the water layer next the deep-sea floor,
— The abyssal fauna inhabiting the deep-sea floor,
— The organisms and processes important to deep-sea sediments.

It was requested that at its Third Meeting in Washington, October 1951, the Executive Board of ICSU would carefully consider the desirability of authorising the continuation of the Joint Commission on Oceanography for a further period of three years.

As provisional secretary of the JCO was nominated Mr. C. D. Ovey, British Museum (Natural History), London S.W. 7.

# Administrative Reports

## Report of the Secretary for the period 1948-51

Two members of the Committee on Oceanographical Observations from Atlantic Weather Ships have been replaced during the period: Director M. H. KEYSER on his resignation by Vice-Admiral J. W. TERMIJTELEN and Professor M. KNUDSEN on his death by Mr. H. THOMSEN.

During most of the period the preparation and distribution of standard sea water has been carried out by the Dépôt d'Eau Normale at Copenhagen under the conduct of Mr. HELGE THOMSEN and at the responsibility of the Association (see p. 18).

Since the General Assembly at Oslo in 1948 the following publications have been issued:

*Procès-Verbaux.*

No. 4. General Assembly at Oslo, August 1948 (1949).

*Publications Scientifiques.*

No. 10. Monthly and Annual Mean Heights of Sea-Level 1937 to 1946 and unpublished data for earlier years (1950).

No. 11. J. P. Jacobsen † and Rex J. Robinson and Thomas G. Thompson: A Review of the Determination of Dissolved Oxygen in Sea Water by the Winkler Method (1950).

All matters in connection with the Oslo Assembly, including the preparation and printing of Procès-Verbaux No. 4, and the printing of Publ. Scient. No. 10 were managed by the retiring secretary, Professor J. PROUDMAN, Liverpool. My sincere thanks are due to Professor PROUDMAN for his many valuable advices.

The above publications have been sent in batches to the National Committees for further distribution.

Throughout the period contact has been maintained with the International Joint Commission on Oceanography by its secretary, Commander R. B. SEYMOUR SEWELL.

*Håkon Mosby*

(The above Report was unanimously adopted by the General Assembly of the Association on 29th August 1951.)

## Financial Report for the Period 1948-51

A summary statement of Receipts and Payments for the period 1st January 1948 to 31st December 1950 and the Balance Sheet for 31st December 1950 are given in the accompanying tables. Separate accounts had to be kept in Liverpool by the retiring secretary, Professor J. PROUDMAN, until 3rd August 1950 and in Bergen by the present secretary. The Liverpool accounts were examined and certified by R. LEWIN, Incorporated Accountant, Liverpool, and the Bergen accounts were examined and certified by AKSEL DALE, Accountant, Bergen. Summaries of both accounts were sent to Dr. J. M. STAGG for publication in the General Secretary's Report. In the accompanying tables both accounts are included, and each amount originally given in sterling has been converted to Norwegian Kroner at the rate of 19.9684, corresponding to the effective rate at which the final Liverpool Balance was actually converted (£ 1 349.4.1 = 26 941.46 kr. N.).

A separate statement of UNESCO grants for the period is given on p. 17. Of the allocation of £ 770 for 1948 for travelling expenses in connection with the Oslo Assembly an unexpended balance of £ 514.5.10 had to be returned.

*Håkon Mosby*

## ACCOUNTS FOR THE PERIOD 1st JANUARY 1948 TO 31st DECEMBER 1950.

*Receipts:*

| | 1948 | 1949 | 1950 |
|---|---|---|---|
| Profit sale War Loan | 1 138.12 | | |
| Interest War Loan | 274.57 | | |
| Allocation from Union | 11 667.48 | 11 667.48 | 11 681.80 |
| Allocations from UNESCO | 15 375.67 | | 1 817.35 |
| Sale of publications | 16.97 | 35.00 | 1 029.68 |
| Bank interests | 52.08 | 203.71 | |
| | 28 524.89 | 11 906.19 | 14 528.83 |

*Payments:*

| | 1948 | 1949 | 1950 |
|---|---|---|---|
| Standard Sea Water Service | 17 971.56 | 5 011 65 | 5 009.65 |
| Salary Helge Thomsen | | 1 245.97 | 725.70 |
| Printing | | | |
| Publ. Scient. No. 9 | 1 026.38 | | |
| Agenda, abstracts | 2 591.40 | | |
| Proc. Verb. No. 4 | | 4 676 10 | |
| Séance Commune | | 1 188.37 | |
| Publ. Scient. No. 10 | | | 7 956.41 |
| Travelling | | 628.25 | |
| Officers AIOP (UNESCO) | 1 696.73 | | |
| Joint Commission (UNESCO) | 2 396.96 | | |
| Scientists (UNESCO) | 1 012.40 | | |
| Bureau | | | |
| Assistance | 210.00 | 60.00 | 720.00 |
| Postages, stationery etc. | 1 026.48 | 265.73 | 221.41 |
| UNESCO, unexpended | 10 269.58 | | |
| | 38 201.49 | 13 076.07 | 14 633.17 |
| | 9 676.60 Deficit | 1 169.88 Deficit | 104.34 Deficit |

## BALANCE SHEET AT 31st DECEMBER 1950.

| | |
|---|---|
| Assets 31/12 1947 £ 3 047.6.3 ..... | kr. 60 849.97 |
| Net deficit 1948—50 ..... | - 10 950.82 |
| | kr. 49 899.15 |
| Cash in bank and hand 31/12 1950 ..... | kr. 49 899.15 |

I have examined the Accounts of the Association of Physical Oceanography for the three years ended 31st December 1950 and hereby certify that the said accounts are in order.

(*Signed*) Aksel Dale (Accountant).

BERGEN, 22nd June 1951.

## UNESCO GRANTS FOR THE PERIOD 1st JANUARY 1948 TO 31st DECEMBER 1950.

*Receipts:*

| | | 1948 | 1950 | |
|---|---|---|---|---|
| I | For travelling expenses of officers of AIOP ..... | £ 450.0.0 | | |
| II | For travelling expenses of members of JCO ..... | £ 260.0.0 | | |
| III | For travelling expenses of distinguished or young scientists | £ 60.0.0 | | |
| | Standard Sea Water Serv... | | £ 91.1.5 | |
| | Total ..... | | | £ 861.1.5 |

*Payments:*

| | | | | |
|---|---|---|---|---|
| | Travelling to and from Oslo | | | |
| I | Officers of AIOP..... | £ 84.19.5 | | |
| II | Members of JCO ..... | £ 120. 0.9 | | |
| III | Distinguished Scientists .... | £ 50.14.0 | | |
| | Repayment to UNESCO of unexpected balance ..... | £ 514.5.10 | | |
| | Standard Sea Water Serv... | | £ 91.1.5 | |
| | Total ..... | | | £ 861.1.5 |

(The above Report was unanimously adopted by the General Assembly of the Association on 29th August 1951.)

# Report on the Activities of the Dépôt d'Eau Normale 1948-1951

The production of Standard Sea Water, which through a long series of years was taken care of by the late professor MARTIN KNUDSEN, was taken over by the AIOP after the General Assembly in Oslo 1948. MARTIN KNUDSEN was charged with the responsibility for the production on behalf of the Association, and after his decease in May 1949, the responsibility was taken over by the undersigned.

In the now expired three-year period three batches of Standard Sea Water were prepared, namely

$P_{17}$ sealed on 31. October 1948. Chlorinity 19.386.
2174 tubes filled.

$P_{18}$ sealed on 2. December 1949. Chlorinity 19.376.
1204 tubes filled.

$P_{19}$ sealed on 6. April 1950. Chlorinity 19.371.
2961 tubes filled.

In the same period 5372 tubes were distributed to users in all parts of the world. Of this amount 2654 tubes were sent to the United States, most of them to the firm G. M. Manufacturing Co. in New York, who has undertaken to stock Standard Sea Water for users in the United States.

Some difficulties were experienced in the purchase of suitable tubes. For $P_{17}$ and $P_{18}$ tubes of Belgian make were used. These were however not fully satisfactory as regards the solubility of the glass. For $P_{19}$ tubes of "Jenaer Geräteglas" were employed. These were satisfactory as regards solubility, but some of them proved not to be perfectly tight. These difficulties, which arise from the post war trade conditions, seem now to have been overcome. For the next batch, $P_{20}$, 3200 tubes have been purchased, and these are fully satisfactory in every respect.

*Helge Thomsen*

(The above Report was unanimously adopted by the General Assembly of the Association on 29th August 1951.)

# Delegates and Guests attending General Assembly

### Austria.

Defant, A.

### Belgium.

Capart, A.
Van Mieghem, J.

### Canada.

Ford, W. L.
Rochford, D. J.

### Denmark.

Smed, J.
Thomsen, H.

### Finland.

Jurva, R.
Lisitzin, E.

### France.

Allard, P.
Boeuf, C. Francis
Fage, L.
Gougenheim, A.
Julien
le Floch, J.
Rouch, J.
Serene, R.
Tardi, M. P.
Tscheltzoff, O.

### Germany.

Böhnecke, G.
Correns, C.

### Great Britain.

Bowden, K. F.
Carruthers, J. N.
Charnock, H.
Cooper, L. H. N.
Corkan, R. H.
Day, A.
Deacon, G. E. R.
Doodson, A. T.

GREAT BRITAIN. (cont.)

Goldsbrough, G. R.
Green, F. H. W.
Hawkes, L.
Hill, M. N.
Lamb, H. H.
Lumby, J. R.
Mortimer, C. H.
Orr, A. P.
Ovey, C. D.
Redfearn, J. B. C.
Schove, D. J.
Sewell, R. B. Seymour
Stride, A. H.
Thompson, Beeby
Thompson, K. H.
Wilson, C. D. V.
Wiseman, J. D. H.

GREECE.

Stassinopoulos, A. C.

ITALY.

Aliverti, G.
Bossolasco, M.
Tenani, Mario
Tupillati, R.
Vercelli, F.
Viglieri, M.

JAPAN.

Hidaka, K.

NETHERLANDS.

Brongersma-Sanders, M.
Dorrestein, R.
Edelman, T.
Groen, P.
Koning, L. P. G.
Kuenen, Ph. H.
Postma, H.
Ritseema, A. R.
Schijf, J. B.
Schönfeld, J. C.
Thijsse, Th.
Umgrove, J. H. F.
Volker, A.
Weenink, M.

NORWAY.

Eggvin, J.
Fjeldstad, J. E.
Holtedahl, H.
Mosby, H.
Sverdrup, H. U.

NEW ZEALAND.

Sladden, E. M.

PHILLIPPINES.

Hizon.

PORTUGAL.

Silva, E. C.
Simoes Mendes, A.

SPAIN.

Balen, Fernando Garcia
Menendez, N.

SWEDEN.

Ekman, J. J.
Jerlov, N.
Koczy, F.
Kullenberg, B.
Pettersson, H.

U.S.A.

Abel, R. B.
Arsenault, A. J.
Austin, T. S.
Beij, K. Hilding
Birch, F.
Clarke, G. L.
Dietz, R. S.
Disney, L. P.
Ewing, M.
Heezen, B.
Lek, L.
Lyman, J.
Pannekock, A. J.
Phleger, F. B.

INTERNATIONAL HYDROGRAPHIC BUREAU.

Nares, J. D.

# General Assembly at Brussels
# August 1951

## Agenda

The items numbered by decimals were not included in the Agenda circulated before the General Assembly.

A. President's Address.

H. U. Sverdrup: Trends in oceanography.

B. Administration.

1. Report of the Secretary for the period 1948—51.
1,1 Report on the Standard Sea Water Service 1948—51.
2. Financial report for the period 1948—50.
3. Financial estimates for the next period.
4. Election of the President, Vice-Presidents and two members of the Executive Committee.
5. Appointment of two representatives on a provisional mixed commission to prepare a Third International Polar Year 1957—58.
6. Appointment of two representatives on a provisional mixed commission to prepare an Upper Atmosphere Nomenclature.
7. Appointment of two representatives on a provisional mixed commission to prepare World Days in Upper Air Research.
8. Nomination of a representative on the International Joint commission on Oceanography.

C. Reports of Scientific Committees.

1. Committee on tides.
2. Committee on mean sea-level and its variations.
3. Committee on nomenclature of ocean-bottom features.
4. Committee on oceanographical observations from Atlantic weather ships.
5. Committee on preparation of technical handbook on physical oceanography.
6. Committee on questions concerning preparation of a bibliography.

D. Appointment of Scientific Committees.

1. Committee on tides.
2. Committee on mean sea-level and its variations.
3. Committee on nomenclature of ocean-bottom features.
4. Committee on oceanographical observations from Atlantic weather ships.
5. Committee on preparation of technical handbook on physical oceanography.
6. Committee on questions concerning preparation of a bibliography.

E. General Reports.

1. Deacon, G. E. R.: The British National Institute of Oceanography.
1.1. Gimenez, L. M.: Trabajos oceanograficos de la Direccion General de Navegacion e Hidrografia.
2. Hachey, H. B.: Physical Oceanography in Canada, 1948—51.
2.1. Hansen, W.: Physikalische Ozeanographie in Deutschland 1945—51.
2.2. Nares, J. D.: Report on the work carried out by the International Hydrographic Bureau.
2.3. Rao, M. B. R.: Note on oceanographic work in India.
3. Stassinopoulos, A. and Laskapides, C.: Greek National Report on Physical Oceanography.
4. Van Veen, J.: Continuous measurements of currents and suspended material on the Netherlands light vessels.

4.1. Serene, R.: Les projects en Océanographie du Conceil Indo Pacifique des Pêches (FAO).
4.2. Francis-Boeuf, C.: La Campagne Océanographique Française du "Calypso".
4.3. Jurva, R.: Oceanography in Finland.
4.4. Laurent, J.: Résultats de la mission d'étude du port de Safi.
4.5. Menendez, N.: Océanographie physique à l'Espagne 1948—51.

F. Symposium: Exploring the Ocean Floor.

1. Pettersson, H.: Stratigraphy and chronology of ocean sediments.
2. Wiseman, J. D. H.: Chemical, physical and mineralogical changes in deep-sea deposits.
3. Phleger, Fred: Foraminifera and paleoceanography.
4. Ewing, Maurice: Seismic investigations in great ocean depths.
5. Bourcart, J.: Recherches sur les gorges sous-marines (submarine canyons) du Golfe du Lion.
6. Brongersma-Sanders, M.: On the origin and environment of marine sapropelium.
6.1. Capart, A.: Le Plateau et le Talus Continental de la Côte Africaine de l'Atlantique Sud.
6.2. Dietz, R. S.: Sea Floor Results: Scripps-Navy Mid-Pacific Expedition, 1950.
6.3. Hill, M. N.: Seimsmic refraction shooting at a point in the Eastern Atlantic.
7. Koczy, F.: On the properties of the water-layers close to the ocean floor.
7.1. Kuenen, Ph. H.: Graded and non-graded deep-sea sands.
8. Ovey, C. D.: Significance of foraminifera as indicators of past climatic changes.
9. Rothé, J. P.: La structure de l'Océan Atlantique.

G. Papers.

*Currents.*

1. Carruthers, J. N.: Some new work on currents-observing in the seas around Britain.
1.1. Currie, R. I.: A survey of the Benguela Current.

2. JERLOV, N. G.: Preliminary notes on the countercurrent in the Indian Ocean.
4. SVERDRUP, H. U.: Circulation and tidal currents underneath the shelf-ice, Queen Maud Land.
6. UDA, M.: On the fluctuation of the main stream axis and its boundary line of Kuroshio.
6.1. WEENINK, M.: A computation of surface current velocities in the central part of the Pacific from wind data.

*Waves.*

7. ALLARD, P.: Forme et énergie de l'onde-marée de vive-eau entre les heaux de Bréhat et le Cap de la Hague.
10. CORKAN, R. H.: Further investigations on North Sea surges.
10.1. CORKAN, R. H.: Storm effects in the Irish Sea.
10.2. DARBYSHIRE, J.: Wave generation.
11. DORRESTEIN, R.: Note on the effect of surface films on ripples.
12. FJELDSTAD, J. E.: Measurements of internal waves.
13. GOLDSBROUGH, G. R.: Theoretical investigations of North Sea surges.
13.1. GULATEE, B. L.: Tidal work in India.
14. LACOMBE, H.: La diffraction de la houle. Une solution practique approchée.
15. TAKAHASI, R.: Estimated damage along the Pacific coast of Japan due to probable future tsunamis.
17. THIJSSE, J.: Energy-supply to wind-generated waves.
17.1. TUCKER, M. J.: Surf beats.
18. YOHIDA, K.: On the ocean wave spectrum, with special reference to the beat phenomena and the "1—3 minute waves".

*Turbulence.*

19. BOWDEN, K. F.: Some observations of turbulence in a tidal current.
20. — The modification of KNUDSEN's hydrographic theorem required by mixing along the current.
21. GROEN, P.: Notes on waves and turbulence.
22. MOSBY, H.: Bottom current fluctuations in the open sea.

*Miscellaneous.*

23. Cahierre, L.: Note sur les variations de niveau moyen de la mer
24. Cooper, L. H. N.: Utilisation of total phosphorus determinations in physical oceanography.
25. Chaubal, A. S., Malurkar, S. L., Panduranga Rao, M.: Sea density observations near Bombay.
25.1. Kullenberg, B.: On the water exchange through a narrow channel connecting a basin with fresh water inflow to the sea.
26. Rouch, J.: Observations d'échos sur la mer avec le radar du Musée Océanographique de Monaco.
27. Takenouti, Y.: On the transparency of sea-water.
28. Volker, A.: The influence of the enclosure of the Zuyderzee on the hydrographic conditions of the adjacent sea-area.
29. Yamaguti, S.: On the change in the height of the mean sea level in Japan.

H. Joint Meeting with the Association of Meteorology.

Symposium: General Circulation of Oceans and Atmosphere.

I. Joint Meeting with the Associations of Meteorology and of Seismology.

Microseisms.

## Excursions

were arranged 1st and 2nd September.

## Visits

to laboratories of hydraulic research at Antwerp and at Ghent 31st August.

# Reports of Meetings

## First General Meeting of the Association

Tuesday, 21st August 1951

The Meeting opened at 14.40, when the Chair was taken by the President, Professor SVERDRUP. Fifty-three delegates and guests were present.

The Supplementary Agenda was approved.

G 7. Dr. ALLARD read his paper: "Forme et énergie de l'onde-marée de vive-eau entre les heaux de Bréhat et le Cap de la Hague" (see p. 165).

Dr. DOODSON made reference to previous work on tidal friction by TAYLOR, JEFFREYS, PROUDMAN and DOODSON, and stressed the importance of the problem theoretically and practically. He congratulated M. ALLARD upon his work as a practical contribution to the theory of turbulence. It has hitherto been customary to regard frictional losses as due principally to bottom friction, but it may be necessary to revise our ideas.

Dr. VOLKER: "Quelles sont les pertes dans les autres parties de la Manche?"

Dr. ALLARD: "Perte pour la Manche totale

| | |
|---|---|
| (chiffres H. JEFFREYS).(60.000 km²) | 110 M kw |
| Perte pour le Golfe de St. Malo (6.000 km²) | 24 M kw |
| Perte pour le reste | 86 M kw |

Les pertes sont dans le Golfe de St. Malo plus fortes relativement que dans le reste de la Manche bien que les courants (sauf Raz Blanchart) n'y soient pas sensiblement plus forts. La loi de perte d'énergie en $\lambda V^3$ (Taylor 1920) me semble applicable à la majeure partie de la Manche mais non à une région de relief très compliqué."

G 10. Dr. CORKAN read his paper: "Further investigations on North Sea surges" (see p. 167).

Professor PETTERSSON: "I suggested in 1921 that the storm-flood of December 1914 was due not to a progressive wave but to *a standing oscillation of the whole North Sea* with its nodal line between the Færoes and Bergen, with a period, calculated by KULLENBERG, of 42 hours. Possibly this standing wave, in support of which some arguments were cited, may have been at least partly due to the sudden filling out of a nearly stationary depression close to that nodal line".

Dr. DOODSON: "Dr. CORKAN'S paper is a contribution to knowledge and does not pretend to be the last word on the subject. His examples are but a few of a great many he has studied, many of them showing the same characteristics of rotation in an anti-clockwise direction. But there are other possible methods of generation and propagation, and observations are required all over the sea in order to examine the problem thoroughly. A beginning has been made by the German Hydrographic Institute, using depth meters observing simultaneously over a large region. Tentative conclusions show that there is great complexity".

G 10.1. Dr. CORKAN read his paper: "Storm effects in the Irish sea" (see p. 170).

# Second General Meeting of the Association

Wednesday, 22nd August 1951

The Meeting opened at 11.20, when the Chair was taken by the President, Professor SVERDRUP. Fifty-three delegates and guests were present.

The President asked that the chief representative of each country should be announced to the Secretary.

B 5. Professor SVERDRUP was unanimously appointed to represent the Association on a provisional mixed commission to prepare a Third International Polar Year 1957—58.

B 6. No representative was appointed for a provisional mixed commission to prepare an Upper Atmosphere Nomenclature.

B 7. No representative was appointed for a provisional mixed commission to prepare World Days in Upper Air Research.

G 11. Dr. DORRESTEIN read his paper: "Note on the effect of surface films on ripples" (see p. 172).

G 12. Professor FJELDSTAD read his paper: "Measurements of internal waves" (see p. 174).

Dr. MORTIMER: "We are finding Dr. FJELDSTAD's theory the only really adequate tool for the interpretation of internal seiche movements which we have found to be a constant feature in stratified lakes. Continous records of temperature at fixed depths illustrate these waves and also the waves of shorter (about 2 hours) period superimposed on them, similar to those illustrated in Dr. FJELDSTAD's second slide.

Dr. HIDAKA: "It appears that the observed amplitudes are especially larger than computed when the amplitudes are large. Can this tendency be explained by the effect of eddy viscosity"?

Professor FJELDSTAD: "No, it can be explained by the increase in section of the fjord".

# Third General Meeting of the Association

Wednesday, 22nd August 1951

The Meeting opened at 14.00, when the Chair was taken by the President, Professor SVERDRUP. One hundred and forty-seven guests and delegates were present at the presidential address, fifty at the rest of the meeting.

A. The President gave his address on "Trends in Oceanography" (see p. 55).

G 17. Professor THIJSSE read his paper: "Energy-supply to wind-generated waves" (see p. 185).

G 13. Dr. GOLDSBROUGH read his paper: "Theoretical investigations of North Sea surges" (see p. 177).

Dr. DOODSON: "In the investigation by PROUDMAN and DOODSON the separate effects of pressure and wind were investigated, and they gave similar results".

Dr. HIDAKA: "May I ask British gentlemen that by surge you mean the rise of water due to pressure only, not including the rise due to the piling up of water by winds against the coast"?

Dr. GOLDSBROUGH replied that "it does not include the piling-up by winds, just the rise of water by pressure difference only".

G 14. Dr. LACOMBE's paper: "La diffraction de la houle. Une solution pratique approchée" (see p. 181) was read by dr. ALLARD.

G 15. Dr. TAKAHASI's paper: "Estimated damage along the Pacific coast of Japan due to probable future tsunamis" (see p. 183) was read by dr. HIDAKA.

# Fourth General Meeting of the Association

Thursday, 23rd August 1951

## Symposium: "Exploring the Ocean Floor"

The Meeting opened at 9.30, when the Chair was taken by the President, Professor SVERDRUP. One hundred and forty-five guests and delegates from the Associations of Physical Oceanography and of Seismology were present.

F 1. Professor PETTERSSON read his paper: "Stratigraphy and chronology of ocean sediments" (see p. 129).

F 2. Dr. WISEMAN read his paper: "Chemical, physical and mineralogical changes in deep-sea deposits" (see p. 130).

F 4. Dr. EWING read his paper: "Seismic investigations in great ocean depths" (see p. 135).

F 6.3. Dr. HILL read his paper: "Seismic refraction shooting at a point in the Eastern Atlantic" (see p. 145).

F 9. Dr. ROTHÉ read his paper: "Discussion sur la structure du fond de l'Océan Atlantique" (see p. 151).

F 7.1. Dr. KUENEN read his paper: "Graded and non-graded deep-sea sands" (see p. 147).

# Fifth General Meeting of the Association

Thursday, 23rd August 1951

## Symposium: "Exploring the Ocean Floor"

The Meeting opened at 14.00, when the Chair was taken by the President, Professor SVERDRUP. Sixty guests and delegates from the Associations of Physical Oceanography and of Seismology were present.

F 3. Dr. PHLEGER read his paper: "Foraminifera and paleoceanography" (see p. 133).

F 8. Dr. OVEY read his paper: "Significance of foraminifera as indicators of past climatic changes" (see p. 148).

Discussion started at 15.00.

Dr. PANNEKOCK: In the $CO_2$ curve Dr. WISEMAN has shown there are a few places where the curve goes to the left. Are these the coldest periods? As these layers are very thin, it would seem that the coldest periods are of a short duration, unless the rate of sedimentation was not the same in the cold periods.

Dr. WISEMAN: Yes, it is correct to say that where the $CO_2$ curve goes to the left the climate is colder, but it is not correct to imagine that the cold periods are of very short duration. If the position of the Mankato phase of the Wisconsin Glaciation is taken as representing the onset of a cold period, it is clear from the graph that some of the cold periods are of considerable duration. Further, the rate of sedimentation is, of course, slower in the cold periods, as the productivity of the planktonic foraminifera is smaller.

Mr. OVEY to Dr. PHLEGER: Are the displaced benthonic foraminifera found in the various areas in large numbers?

Prof. PHLEGER: It is my impression that displaced faunae are of local distribution.

Mr. OVEY: I am interested in Dr. PHLEGERS' reply because we have specimens in the Museum collections found on drifting vegetation which obviously would go long distances from their proper environment e.g.: Orbitolites attached to a eucalyptus leaf found many miles away from Australia.

Prof. KUENEN to dr. HILL: Would a sea anchor be effective in preventing the drifting of the sono-radio buoys?

Dr. HILL: It would be necessary to anchor the sono-radio buoy to the water at the depth of the hydrophone. The surface drift of the water due to wind will not be far different from the velocity of drift of the buoy.

Prof. KUENEN to Dr. PHLEGER: How long could the paleogeography be extended into the past on the basis of foraminifera?

Prof. PHLEGER: These results probably can be applied with certainty back to the early Tertiary, perhaps as far as the Lower Cretaceous. Beyond that, I have no opinion.

Dr. KULLENBERG: As Dr. WISEMAN's diagram represents the variations of the $CO_2$ content of the sediment, the very sharp "cold" throughs referred to by Dr. PANNEKOCK, do not represent quite as sharp temperature change, because, although there is a certain connection between $CO_2$ content and temperature, it is no linear one.

Dr. CARRUTHERS: How confident are the palaeontologists in the matter of no change in temperature tolerance on the part of foraminifera? Further, does a given organism from the past necessarily indicate the same temperature as it does in these days.

Prof. PHLEGER: Foraminifera have a very complex adjustment to their environments, although temperature is an important factor. I think we can apply these data to the more recent geologic past, at least.

Dr. ORR pointed out that in Dr. WISEMAN's diagram the agreement between the two curves was striking and asked whether P & N analyses had been made to confirm the $CO_2$ results. He also asked whether Mr. OVEY like Dr. PHLEGER had found solution, and deposition of $CaCO_2$ in the cores.

Dr. WISEMAN: In answer to the question whether P & N determinations had been carried out on the core I may say that we will shortly undertake this work.

Mr. OVEY to Dr. ORR: Some traces of solution of foraminifera has been found in Core 241 with broken shells partially dissolved, but outstanding peaks of solution are not in evidence. Recrystallization of the kind mentioned by PHELEGR has also been noted.

Dr. COOPER: I would like to point out the danger of assuming that the oceanographical conditions of the past were similar to those of to-day. Dr. C. E. P. BROOKES in his book "Climate through the Ages" has made a strong case that past climates have mostly been very much warmer than now. The surface water has been warmer and the method of production of bottom water and its properties such as pH, may also have differed greatly. Conditions favouring solution of bottom calcareous shells should also have been most favourable during glacial periods and unfavourable during warm periods. Moreover, it now seems that the understanding of the inorganic calcium carbonate system based on the work of WATTENBERG, CORRENS, REVELLE and FLEMING and SMITH has been insufficient to explain the events in nature. The lowering of pH at surfaces by as much as 2 pH units below that of the bulk phase and the possibility that calcium may lose its ionic character by some form of complex formation with organic substances must be taken into account.

Prof. PETTERSSON to Dr. COOPERS' remark: What about magmatic acids which may have contributed to the solution of lime? Red-clay cores of Tertiary age can hardly be explained as a result of solution by cold bottom currents. Concerning Dr. HILL's paper: Prof. WEIBULL, who has perfected his reflection method by using the wire recorder for registering the echoes has also been making measurements of the velocity of sound in samples from deep-sea sediment cores. This work will shortly be published.

Dr. WISEMAN: I am very pleased to hear Prof. PETTERSSONS views about the solution of calcium carbonate, as I have long held the opinion that the normal physical and chemical processes do not give an adequate answer to the known distribution of calcium carbonate. For example, the low content of calcium carbonate

in certain portions of the Arabian Basin as well as in the North Pacific Basin cannot be explained on simple physical-chemical grounds. It is of some significance to note that in the North Pacific Basin there is abundant evidence of vulcanism, and it may be that this cause is responsible for the low content of lime in certain areas.

In the core which we have investigated, there is no evidence of vulcanicity, and in consequence the variations in $CO_2$ cannot be ascribed to this cause. Nor does it seem likely, for reasons which I briefly mentioned in my paper, that the major $CO_2$ changes can be accounted for by assuming differing rates of lime solution by the bottom water during the geological past.

Dr. WISEMAN: I would like to ask Dr. PHLEGER whether the occurrence of planktonic foraminifera at great depths may be explained by the fact that the foraminifera were dead; in other words, that they were sinking into the deep-sea floor. Also, would not any staining test used to detect whether the planktonic foraminifera were dead or alive work equally well if the protoplasm had not decayed?

Prof. PLEGER: Identification of the living fauna is based upon presence of protoplasm. This is based upon the assumption that protoplasm decomposes immediately upon death. It appears most probable that they were alive.

Mr. OVEY: In a recent excellent report, Dr. PHLEGER & Miss PARKER record the greatest abundance of living planktonic foraminifera at 25 meters depth. In addition, the speaker has in the British Museum collections some of the original slides mounted on board the first H.M.S. CHALLENGER, in which nearly all foraminifera from surface water planktonic samples are of young specimens. These facts suggest that planktonic foraminifera at least live near the surface in their young stages and probably breed there.

Dr. WILSON: I should like to ask Dr. EWING two questions:

a) Have the cores from the bottom of the Puerto Rico Trench been compared with the sedimentary rocks of Barbadoes or other islands of the outer sedimentary arc? It has been suggested that the islands of the outer arc of island arcs have been raised from trenches and should perhaps have similar sediments.

b) Has Dr. EWING gravity data which would support his interpretation of the seismic data over the Puerto Rico Trench?

Prof. EWING: a) Sediments of Puerto Rico Trench are dark, highly calcareous, stratified and have a level upper surface. Sediments of the walls of the trench — even only slightly above the bottom depth — are red clay. The thickness of the sediment layer is estimated at 10 km.

b) The absence of sialic layer under the Atlantic has weakened the explanation of the gravity minimum associated with the Puerto Rico Trench in terms of a downbuckle in the sialic crust. The absence of sialic crust under the Caribbean has increased the difficulty. It is suggested that the prism of sediment in the rough contributes greatly toward the gravity anomaly.

Dr. LYMAN: What is the possible effect on cores of burrowing benthonic animals, such as are frequently photographed in deep water?

Dr. WISEMAN: In my opinion, boring organisms have not upset appreciably the original stratification in the core which we have investigated. I have naturally examined the core for traces of disturbances caused by such organisms, or for disturbances caused through mud flows or density currents, and in my opinion, the original stratification of the core has not been upset.

Dr. EWING: We can produce examples of deep-sea sediments entirely free burrows, examples with occasional burrows, and examples completely disturbed by their mechanisms.

Prof. PETTERSSON: Experience from the Pacific cores investigated by Dr. ARRHENIUS prove that in certain cores the action of boring organisms is evident, in other cores practically absent. ARRHENIUS estimates that in most cases such a reshuffling by boring organisms is not active over more than a few centimeters.

Dr. CARRUTHERS remarked upon the complications which arise from the 4-fold stratification of the ocean and from the fact that sometimes the $CaCO_3$ is hexagonal and sometimes rhombic.

Is there not perhaps some organism with siliceous test that

can serve as the temperature indicator, so avoiding many difficulties?

Prof. PHLEGER: Radiolaria and diatomes have been used. They are less wellknown and more difficult to study than foraminifera. They also are subject to solution.

Dr. WISEMAN: Although I cannot answer the biological points raised by Dr. CARRUTHERS, it may be possible to obtain by quite independent means the conformation that the peaks of the $CO_2$ curve are warm and the troughs colder. The proportion of the O isotope to O in calcium carbonate has recently been shown to be dependent on the temperature of the water at the time when the calcium carbonate was deposited. It may be possible by this means to show that the peaks of the $CO_2$ curve are warmer than the troughs, provided that the whole of calcium carbonate content of the foraminiferal shells was deposited from sea-water of relatively constant temperature. In other words, O investigations may show whether planktonic foraminifera are stenothermic throughout their life, or whether they are stenothermic during reproduction and eurythermic during their other life phases.

Prof. KUENEN: How are planktonic organisms reproduced at the origin of a current, a point from which they are continually being carried away? Has Prof. EWING any information bearing on ROTHÉ's hypothesis of a fundamental difference between the western & eastern Atlantic?

Mr. OVEY to Dr. KUENEN: In waters of warmer origin in low temperature areas, a few hardy warm-tolerating specimens are bound to survive, but when such specimens reproduce there is likely to be a very great mortality in the young. Conversely, water of cold origin is unlikely to contain any, although the temperature of surface waters might in each case be the same.

Dr. PANNEKOCK: Mr. ROTHÉ is of the opinion that in the eastern half of the Atlantic Ocean there exists conditions similar to those below the continents. In the South Atlantic the Mid-Atlantic ridge diverges very much from the African coast so that a wide ocean basin lies between them. Would this be a convenient place to execute refraction seismic work in order to decide on this question? It is possible that some intermediate conditions would be found there.

Prof. EWING: Seismic refraction work between the Mid-Atlantic Ridge and Europe and Africa is highly desirable and would be undertaken if ships were available. The measurements which we have made between the Azores and Madeira as well as in the deep waters of the Bay of Biscay, show no evidence of a sialic crust.

# Sixth General Meeting of the Association

Friday, 24th August 1951

## Symposium: "Exploring the Ocean Floor."

The Meeting opened at 9.30, when at the request of the President, the Chair was taken by Commandant ROUCH. Fifty-seven delegates and guests were present.

F 5. Dr. BOURCART's paper: "Recherches sur les gorges sous-marines (submarine canyons) du Golfe du Lion" (see p. 137) was read by M. FRANCIS-BOEUF.

Dr. CAPART: "La Nature du plateau continental au large de Marseilles est il constitué de sediments consolidés ou meulles"?

M. FRANCIS-BOEUF: "Concernant la topographie du „socle continental" (Borderland) le socle n'est decoupé par les canyons qu'á partie de 90—100 m. Entre cette profondeur et le littoral actuel il n'y a pas traces de vallées, mais il est possible que leur cours anterieur soit ou tronqué par le quarternaire grèseuse ou au contraire complètement obturé".

Dr. PANNEKOCK: "Est-ce qu'il y a des indications d'ordre géologique pour un éffondrement post-villafranchien d'un des bassins de la Méditerranée? On sait qu'il y a aussi des hypothèses sur une origine sous-marine des canyons sous-marins. Il est donc important que l'hypothèse d'un affaissement assez récent dans la Méditerranée soit soutenue par des arguments géologiques. On pourrait penser par exemple á la grande épaisseur de depots calabriens marins dans certains bassins d'Italie, ce qui indiquerait un affaissement".

M. FRANCIS-BOEUF: "A propos de la date de creusement primaire de ces canyons, BOURCART pense que ce creusement a eu lieu au Villafranchien, mais je ne possède pas les arguments qui lui permettent cet énoncé".

G 1.1. Dr. CURRIE's paper: "A survey of the Benguela Current" (see p. 155) was read by Dr. CHARNOCK.

F 6. Dr. BRONGERSMA read her paper: "On the origin and environment of marine sapropelium" (see p. 139).

Dr. KUENEN: "I suggest you should not emphasize the number of animals preserved at Holsmaden as proving favourable conditions. The number preserved per year is quite small, because the deposit accumulates very slowly. But I agree with your contention they probably lived in the immediate neighbourhood of where they are now found".

Dr. WISEMAN: "I would like to express my very great admiration for Mrs. BRONGERSMA's paper. Many of us present will have read her former papers on these highly productive regions of the world as well as origin of petroleum and the relation between red water and fish mortality.

F 6.1. Dr. CAPART read his paper: "Le plateau et le Talus Continental de la Côte Africaine de l'Atlantique Sud" (see p. 141).

Dr. ALLARD: "Un relief frangerant analogue à celui du plateau continental Congolais a été trouvé sur la côte marocaine entre Safi et Mogador dans les sondages effectués par le Comité d'Etudes des Côtes du Maroc en 1948 et par la Mission Hydrographique des Côtes de France et d'Afrique du Nord en 1950. L'origine de ce relief n'a pas été éclaircie, aucun échantillon du fond n'ayant été pris".

F 6.2. Dr. DIETZ read his paper: "Sea Floor Results: Scripps-Navy Mid-Pacific Expedition, 1950" (see p. 143).

Dr. BULLARD read a supplement to this paper.

Dr. WISEMAN: "I would like to take this opportunity of expressing my very great appreciation of the very important discoveries made by the Scripps-Navy Mid Pacific Expedition of 1950. They have shown for the first time that the guyots under investigation were truncated in upper Cretaceous times, and that they have discovered a new major tectonic feature in the Pacific — namely the ridge between the Hawaiian Islands and Wake Island.

# Seventh General Meeting of the Association

Friday, 24th August 1951

The Meeting opened at 14.00, when the Chair was taken by the President, Professor SVERDRUP. Forty-four delegates and guests were present.

F 7. Dr. KOCZY read his paper: "On the hydrographic properties of the water layer close to the ocean bottom" (see p. 146).

Dr. COOPER: "I compliment Dr. KOCZY on obtaining unexpected results which are much needed and appear to be above criticism. Hexactinellid sponges may play a part. It is very difficult to visualize any physico-chemical mechanism which will explain what has been observed".

Dr. JERLOV: "During the Swedish Deep Sea Expedition the total content of suspended particles was studied by means of a Tyndall-meter. It was often found that a cloud of particles is present 20—50 m above the bottom, whereas the water below that cloud is very clear. There is no obvious correlation between the amount of particles and hydrographical factors as shown by KOCZY. An explanation would be that sediments are carried off from adjacent ridges by currents. This suggests that the bottom currents are strong and of varying strength — which is in agreement with facts shown by DIETZ to-day".

G 24. Dr. COOPER read his paper: "Utilisation of total phosphorus determinations in physical oceanography" (see p. 199).

Dr. MORTIMER: 1) "How far could total silica be used as a label in the same way as Dr. COOPER proposes for total phosphorus"? 2) "How important are exchanges of phosphorus (e. g. absorption of phosphate) with the bottom"?

Dr. COOPER: 1) "It could, providing a simple method of getting siliceous matter in solution could be achieved. However, there is much conflict of evidence and opinion as to how particulate siliceous dissolves in sea-water (see COOPER: Town. Mar. Biol. Assoc. 1952, in press)".

2) "I believe that muddy areas frequently cause enrichment of the overlying area with phosphorus, placing on such water a

distinctive label, which could be recognized when the water moves on. Over sandy and rocky bottom in shelf waters, I believe that the content of phosphorus in the water does not change much, so that the water remains recognizably the same.

G 25. Drs. CHAUBAL, MALURKAR and PANDURANGA's paper: "Sea density observations near Bombay" (see p. 201) was read by title.

G 25.1. Dr. KULLENBERG read his paper: "On the water exchange through a narrow channel connecting a basin with fresh water inflow to the sea" (see p. 203).

Dr. VOLKER: "Which were the practical purposes for these investigations"?

Dr. KULLENBERG: "Sewage products accumulating in the deeper parts of the landlocked basin in the vicinity of Stockholm, it was expected that it might be possible to prevent such an accumulation by a deepening of the strait. The purpose of the investigation has been to find out whether the water exchange could be expected to be intensified sufficiently much by a deepening to secure the removal of the sewage products".

G 26. Commandant ROUCH read his paper: "Observations d'échos sur la mer avec le radar du Musée Océanographique de Monaco" (see p. 205).

Dr. KUENEN: "Est-ce-que les images changent rapidement? Par example à cours de quelques heures?"

Commandant ROUCH: "Les échos sur la mer ne paraissent pas changer d'aspect pendant plusieurs heures consécutives, mais généralement ils disparaissent très brusquement par mer calme, souvant en quelques minutes".

G 27. Dr. TAKENOUTI's paper: "On the transparency of sea-water" (see p. 208) was read by title.

G 28. Dr. VOLKER read his paper: "The influence of the enclosure of the Zuyderzee on the hydrographic conditions of the adjacent sea-area" (see p. 210).

Dr. VERCELLI read a supplement (see p. 211).

Dr. CAPART: "Les calcules du nivellement de la côte belge effectués par M. JONES montrent les mêmes valeurs de variation du niveau de la mer soit $\pm$ 6 cm par 50 ans".

G 29. Dr. YAMAGUTI's paper: "On the change in the height of the mean sea level in Japan" (see p. 213) was read by title.

# Eighth General Meeting of the Association

Tuesday, 28th August 1951

The Meeting opened at 9.30, when at the request of the President, the Chair was taken by dr. CARRUTHERS. Forty-five delegates and guests were present.

G 19. Dr. BOWDEN read his paper: "Some observations of turbulence in a tidal current" (see p. 189).

G 20. Dr. BOWDEN read his paper: "The modification of KNUDSEN'S hydrographic theorem required by mixing along the current" (see p. 191).

Professor MOSBY wanted to congratulate Dr. DOODSON who has designed this very sensitive current meter, and Dr. BOWDEN, whose series of observations have unveiled such extremely interesting phenomena in the sea. In order to save time, he would postpone further questions till after presenting his own paper.

Dr. HIDAKA: "I remember you have once determined the coefficient of lateral mixing in the Irish Sea, and you now determined the longitudinal coefficient. Which of them will be larger?"

Dr. BOWDEN: "The value of the coefficient of horizontal eddy diffusion deduced by this method for the Southern Entrance is of the same order as that obtained previously from considerations of heat transfer in the central part of the sea. However, for this part of the sea, the value of K deduced for heat transfer is greater than that deduced for salt transfer. Whether there is any significance in this difference is still uncertain.

To questions from Mr. Charnock, dr. BOWDEN answered: "Some further comparisons of our observations with the theory of locally isotropic turbulence will be published in the full account of this work. The similarity with the equation $r = 1 - C\varkappa^{\frac{2}{3}}$ is in the form of the function. No correspondance has yet been established in the value of the constant C. — A greater length of record would probably not influence the first part of the autocorrelation curve, for intervals up to, say 10 or 20 sec. The length

of record might be longer than 10 min. with advantage, but should be still short compared with the tidal period".

Dr. LUMBY: "I should like to congratulate Dr. BOWDEN on his work on the current through the Irish Sea. There should be sufficient data available for the application of the principles employed to the North Sea, for example; although many observations have been made over a long time in this region, the conditions are not yet fully understood".

Dr. BOWDEN: "An application of the ideas of horizontal mixing to the North Sea would certainly be of interest. The details of the application might have to be modified, compared with that used for the Irish Sea".

Dr. DORRESTEIN: "The conclusion of the speaker that the length-scale of turbulence in the direction of the main flow is several times larger than that in the directions perpendicular to it was based on the assumption that there is a direct connection between time-autocorrelation and the distance correlation in the direction of the main flow, given by the factor U (mean velocity). Perhaps this assumption is not valid? And there is a factor *less* than U? On what is this assumption based"?

Dr. BOWDEN: "The assumption that the auto-correlation for a time interval $\tau$ may be taken to correspond to a distance $U\tau$ is commonly made in the study of turbulence in air (wind-tunnel), and may probably be justified by analogy for turbulence in water. It is, however, a point which deserves further investigation".

Professor SVERDRUP congratulated the speaker on his results. He considered it particularly important that the value of the coefficient of lateral mixing was found to agree closely with values obtained for areas of similar dimensions by entirely different methods. He felt that BOWDENS work had materially helped to put our knowledge of the character of turbulence in the sea on firmer ground.

Dr. CARRUTHERS said that, before long, the Liverpool workers would be supplied with data presenting actual water travel in the Irish Sea — to be obtained with a variety of methods. He asked that Dr. DODSON would describe the device used with his current-meter to reveal whether the instrument cage remained upright — and supposed that, for near-bottom observations, it should be known that the silt burden of the water remained constant.

Dr. DOODSON: "To detect deflections from the vertical, a short rod hanging vertically within a small ring indicates by electrical contact with the ring the fact of the meter not being vertical within the desired limits. — As to the effect of varying silt content in causing apparent pressure charges, that is an added complication which will require investigation by more complicated apparatus".

G 21. Dr. GROEN read his paper: "Notes on waves and turbulence" (see p. 193).

Dr. FRENKEL: "I should like to make two comments which may be due to my lack of familiarity with oceanography. — The author seems to have reasons not to believe in the possibility of obtaining a wave motion as a consequence of dynamic instability. I have the impression that some similarity to the instability of a laminar motion of fluid dynamics could perhaps be made. If for instance in a laminar motion a certain favourable frequency of fluctuation is introduced, this frequency may amplify and start a strong wave motion which will soon become more and more disorderly and transform in what we call turbulent motion.

The second comment concerns the difference between wave motion and turbulent motion. In many turbulent fields the correlation curve presents negative values and is greatly similar to what the author presents for the wave motion. One can, observing a correlation curve, notice a certain frequency and indicate that the wave motion is responsible for this frequency. However, the turbulent motion contributes as well to this frequency and a clear separation is difficult".

Dr. GROEN: "In answer to the first question it may be remarked that I have not said that I don't like dynamic instability, but only that I don't believe that dynamic instability gives rise to waves in the proper sense of the record.

As to the second question: Waves do have an oscillating type of correlation function, but on the other hand any oscillating correlation function does not necessarily imply waves, since convertion cells may also give such correlation functions".

Dr. BOWDEN: "In connection with the observations of turbulence which I have described, we made observations of salinity and temperature and considered the possibilities of internal waves.

From the criterion given by G. I. TAYLOR, it appeared that internal waves would be possible, at least at some distance above the bottom, but no definite periods could be predicted. It seems possible that, in the same vertical line, internal waves would appear to be stable at mid depths, where the density gradient predominates, but unstable near the bottom, where the velocity gradient predominates".

G 22. Professor MOSBY read his paper: "Bottom current fluctuations in the open sea" (see p. 195).

G 4. Professor SVERDRUP read his paper: "Circulation and tidal currents underneath the shelf-ice, Queen Maud Land" (see p. 157).

Dr. LUMBY: "Has Professor SVERDRUP taken any measurements of the temperature in the ice itself"?

Professor SVERDRUP: "Yes, the measurements show a constant temperature of about $-17°$ C below a depth of about 12 m and to 30—40 m, that is as deep as the measurements go. Above 12 m the annual variation prevails. Towards the bottom the temperature must increase towards freezing point".

# Ninth General Meeting of the Association

Tuesday, 28th August 1951

The Meeting opened at 14.00, when the Chair was taken by the President, Professor SVERDRUP. Fifty-two delegates and guests were present.

G 1. Dr. CARRUTHERS read his paper: "Some new work on current-observing in the seas around Britain" (see p. 153).

A supplement to this was read by Dr. BÖHNECKE (see p. 154).

Dr. LUMBY: "Dr. CARRUTHERS kindly sends me his current-meter data for inclusion in the synoptic charts we publish; these are shown as 10-days residuals. If there is anyone else, making similar observations, who would care to let me make similar use of them for these charts, I should be grateful if they would get in touch with me. — With regard to Dr. BÖHNECKE's paddle-wheel current-meter, is there any arrangement by which the mechanism can be stopped during the operation of mooring"?

Dr. BÖHNECKE: "Es ist kein besonderer Mechanismus vorhanden, der das Uhrwerk *in See* in Tätigkeit setzt. Der erste Zeitkontakt wird *vor* dem Aussetzten des Instrumentes genommen, der letzte *nach* dem Aufnehmen und mit dem Chronometer verglichen.

At the request of the President, the Chair was taken by Dr. CARRUTHERS.

G 2. Dr. JERLOV read his paper: "Preliminary notes on the countercurrent in the Indian Ocean" (see p. 156).

G 23. Dr. CAHIERRE read his paper: "Note sur les variations de niveau moyen de la mer" (see p. 196).

Dr. VERCELLI: "J'ai déjà anticipé quelques observations sur le sujet illustré par M. Cahierre. Avec plaisir je constate qu'il y a un accord complet avec les donnés presentés par M. CAHIERRE et je rappelle encore une fois l'attention sur l'importance de ce problème".

Dr. TSCHELTZOFF: "Il est important de se baser aussi sur des feuilles archéologiques. En effet les feuilles archéologiques effectuées dernièrement dans le port de Marseille ont montré que le niveau des quais du port "ancien" grec est au même niveau, environ, que le niveau moyen actual de la Méditerreanée. — Cette découverte, de grande importance, prouverait plutôt que depuis l'époque grec, il n'y a pas eu, dans cette region, d'ascention continue du niveau moyen de la mer".

Dr. DOODSON: "Has any attention been paid to the possible changes in the direction of the prevalent winds? There is a difference of 7 inches between the south and north of England, which must be attributed to the prevalent wind, but there are regions in the world where there are undoubtedly changes taking place".

Dr. CAHIERRE: "No attention was paid to the possible influence of the winds. I noticed that the mean level is not the same in the different tidal stations in France".

Dr. CARRUTHERS remarked upon the importance of dr. CAHIERRE's paper in connection with isostatic recovery of certain lands, to coast drowning as in the Netherlands — and to questions of delatation due to warming — as studied by another Frenchman (Le Grand?)"

G 6. Dr. UDA's paper: "On the fluctuation of the main stream axis and its boundary line of Kuroshio" (see p. 158) was read by title.

The Chairman asked dr. HIDAKA to convey the delegates' thanks to dr. UDA for his paper.

G 6.1. (H 3) Dr. WEENINK read his paper: "A computation of surface current velocities in the central part of the Pacific from wind data" (see p. 161).

# Tenth General Meeting of the Association

Wednesday, 29th August 1951

The Meeting opened at 9.30, when the Chair was taken by the President. Forty-one delegates and guests were present.

B 1. The Secretary submitted his Report for the period 1948—51 (see p. 14). This was adopted unanimously.

Mr. HELGE THOMSEN gave a report on the activities of the Dépôt d'Eau Normale 1948—51 (see p. 18). This was adopted unanimously.

B 2. The Secretary submitted the Financial Report for the period 1948—51 (see p. 15). This was adopted unanimously.

B 3. The Secretary submitted the following Financial Estimates for the period 1951—54, prepared by the Executive Committee.

Average Expenditure for each Year:

| | | |
|---|---|---|
| Cost of publications | N. Cr. | 11 000 |
| Standard Sea Water | - | 3 500 |
| Bureau | - | 1 500 |
| Travel, officers AIOP | - | 1 500 |
| | N. Cr. | 17 500 |

These Estimates were adopted unanimously.

B 4. The Assembly then proceeded to the election of new Officers and Executive Committee in accordance with the Statutes and By-laws of the Association. On behalf of the Executive Committee Dr. CARRUTHERS made nominations. The new officers and members of the Executive Committee were then unanimously elected as given on p. 9.

B 5. Professor SVERDRUP reported on the meeting concerning a Third International Polar Year 1957—58 and announced that a proposal for resolution would be put before the general meeting next morning.

B 8. It was agreed unanimously that Dr. KUENEN should replace Professor B. HELLAND-HANSEN, who wanted to retire, as a representative on the International Joint Commission on Oceanography.

C 1. The report of the Committee on Tides is printed on p. 66.

D 1. It was agreed unanimously that the Committee on Tides should be re-elected in whole as given on p. 10.

C 2. Vice-Admiral NARES submitted the report of the Committee on mean sea-level and its variations (see p. 67). This report was adopted unanimously, together with the recommendation included in it.

D 2. Dr. DOODSON proposed that the Committee on mean sea-level and its variations should be supplied by Dr. DISNEY, U.S.A. and Dr. EGEDAL, Denmark (p. 10) and should continue its work. This proposal was unanimously adopted.

C 3. Dr. WISEMAN submitted his report of the Committee on nomenclature of ocean-bottom features (see p. 69). The recommendations submitted were all adopted (see p. 72—73).

D 3. It was agreed unanimously that the Committee on nomenclature of ocean-bottom features should be reappointed as given on p. 10 and continue its work.

C 4. Professor MOSBY submitted the report of the Committee on oceanographical observations from Atlantic weather ships, (see p. 74). This report was adopted unanimously.

D 4. It was proposed by Professor MOSBY that in the Committee on oceanographical observations from Atlantic weather ships Dr. LUMBY should replace Dr. FLEMING, and that Dr. LYMAN should be elected as member. This was unanimously agreed to (p. 10).

C 5. Professor SVERDRUP submitted the report of the Committee on preparation of technical handbook on physical oceanography (see p. 76). This report was adopted unanimously.

D 5. It was agreed unanimously that the Committee on preparation of technical handbook on physical oceanography should continue its work and have the same members (see p. 11).

It was agreed that the handbook should be sent to each adhering country in number of copies according to category of membership.

C 6. Dr. GROEN submitted his report of the Committee on questions concerning preparation of a bibliography (see p. 77). The report as well as the recommendations were unanimously adopted.

D 6. It was agreed unanimously that the Committee on questions concerning preparation of a bibliography should continue its work (see p. 11).

# Eleventh General Meeting of the Association

Thursday, 30th August 1951

The Meeting opened at 9.30, when the Chair was taken by the President, Professor SVERDRUP. Thirty-four delegates and guests were present.

B 5. Professor SVERDRUP put before the meeting the announced proposal for a resolution from the provisional mixed commission concerning a Third International Polar Year 1957—58 (see p. 54). The resolution was adopted unanimously.

E 1. Mr. DEACON's report: "An account of the British National Institute of Oceanography" (see p. 80) was read by Mr. CHARNOCK.

G 17.1. Mr. TUCKER read his paper: "Surf beats" (see p. 186)

E 1.1. The report of Dr. GIMENEZ: "Trabajos oceanograficos de la Dirreccion General de Navegacion e Hidrografia" (see p. 81) was read by title.

E 2. Dr. HACHEY's report: "Physical Oceanography in Canada, 1948—51" (see p. 86) was read by Mr. FORD.

E 2.1. Dr. HANSEN's report: "Physikalische Ozeanographie in Deutschland 1945—51 (see p. 90) was read by Dr. BÖHNECKE.

E 2.2. Dr. NARES read his report on the work carried out by the International Hydrographic Bureau (see p. 104).

Professor SVERDRUP tendered to the International Hydrographic Bureau the cordial thanks of the Association for the work carried out.

Dr. WISEMAN submitted the following resolution: "The Association of Physical Oceanography wish to express their gratitude to the International Hydrographic Bureau for the valuable work and support they have given to the science of Oceanography, es-

pecially in connection with the maintenance of Les Cartes Bathymétriques which are of great scientific importance". This resolution was unanimously adopted.

E 2.3. Dr. RAO's report: "Note on oceanographic work in India" (see p. 108) was read by title.

E 3. Dr. STASSINOPOULOS read the "Greek National Report on physical oceanography" (see p. 111).

E 4. Dr. VAN VEEN read his report: "Continuous measurements of currents and suspended material on the Netherlands light vessels" (see p. 115).

E 4.1. Dr. SERENE read his report: "Les projets en Océanographie du Conseil Indo Pacifique des Pêches (FAO) (see p. 117).

Dr. DOODSON proposed that: "The Association records its thanks to those countries and organizations which have contributed reports in their activities. It is suggested that in future each adhering country will present a report of its activities, and it is also suggested that each report be accompanied by a brief bibliography". This proposal was unanimously adopted.

E 4.2. Professor FRANÇIS-BOEUF read the report: "La Campagne Océanographique Francaise du "Calypso" (see p. 119).

E 4.4. M. LAURENT'S report: "Résultats de la Mission d'étude du port de Safi" (see p. 125) was read by Dr. GOUGENHEIM.

E 4.5. Professor MENENDEZ gave in his report: "Océanographie Physique à l'Espagne" (see p. 127).

E 4.3. Professor JURVA gave in his report: "Oceanography in Finland" (see p. 123).

After the Meeting the following films were shown by amiability of the U.S. Hydrographic Office.

1. Oceanographic Station
2. Bathythermograph Lowering
3. Internal Waves

# General Resolution

Adopted by the General Assembly of the Union on the 1st September 1951, on the recommation of the Association.

Considering that the importance of Oceanic depths to Geodesists and Geophysicists has so increased as to require the publication of up-to-date world wide bathymetric charts, the International Union of Geodesy and Geophysics recommends that this should be effected by a Permanent Bureau and that appropriate financial agreements should be made to this end.

# General Resolution

Adopted by the General Assembly of the Union on 1st September 1951, on the recommendation of a joint sub-committee of the Associatons of Terrestrial Magnetism and Electricity, Meteorology, Physical Oceanography and Hydrology.

The International Union of Geodesy and Geophysics approves in principle the recommendations (a), (b), (c) and (d) by the Mixed Commission on the Ionosphere, but wishes to observe that in the fields of meteorology and terrestrial magnetism, with which the Union is particularly concerned, the activity in the polar regions is at present so great that a considerable expansion cannot be expected.

The Association of Meteorology wishes to draw attention to the great importance of the World Meteorological Organisation and to suggest that this organisation be invited to be represented on a Polar Year Commission.

For Resolutions and Recommendations adopted by the Association see pp. 50, 51, 52, 53, 67, 72, 73, 79.

# Presidential Address

## Trends in Oceanography

By
H. U. SVERDRUP

One of the privileges of a person of mature years is to look back and to review developments which in part he has watched, and also to wonder what the future may have in store. Reviewing is always dangerous because the reviewer may easily overlook important steps, he may place the emphasis in the wrong place, or he may let his own personal interest color his presentation. I do not expect to avoid any of these pitfalls, but still I wish to attempt a brief survey of the major features of the growth of physical oceanography in order, perhaps, to place the present rapid expansion against its broad background.

In oceanography as in all branches of geophysical sciences the development reflects the interplay between observations and interpretations, between the accumulation of empirical knowledge and the application of theoretical considerations. In many instances the ultimate goal of our efforts is to predict future events, and in this case we often advance by three steps. At the first step we try to give rational descriptions of the observed conditions, at the second step we try to discover time and space relationships, and at the third step we attempt to account for the events in terms of our knowledge of the laws of physics. We can, I believe, recognize these steps if we examine the progress made when dealing with specific problems, although in most cases we are still far from our goal of making predictions. Similarly, looking back one may observe that during the early years of oceanography the description of the observed conditions naturally took the broadest place, but later on time and space relationships were recognized and still

later interpretations were made in the light of established laws of physics. In general the development has not proceeded at an even pace, but on several occasions the applications of new techniques of observations or of new theoretical results have given new impulses and have lead to sudden expansions of the oceanographic activity.

It seems, however, that in the history of oceanography one topic stands in a separate class, because the basic theory was developed nearly two centuries ago, a theory which served to increase our understanding of the events and to make possible the systematic arrangement of our observations. I refer to the tides which repeat themselves with such astronomic regularity that when dealing with them the problem of prediction has been solved with a high degree of accuracy. Fairly accurate predictions can be made on a strictly empirical basis, but for the preparation of the exact tide tables the basic theory has been indispensable. It furnishes the fundamental knowledge of the periods which may be expected and thus the means for carrying out harmonic analysis of the observed variations. However, our actual understanding of the tides is still incomplete because the simple theory renders only the periods of the tides and the relative magnitudes of the different terms under ideal conditions. The actual tides are extremely complicated because of the shapes of the ocean basins and the effect of the rotation of the earth. In the study of the tides steady progress is being made partly by new theoretical analysis and partly by the re-examination of observed conditions in the light of earlier theoretical results. The field offers excellent examples on the interplay between theory and analysis of observations.

The tides represent a special case of wave motion. Turning to the general case of wave motion the development has been somewhat similar but more stepwise. The classical theories of short waves and of waves at an interface in a liquid was advanced more than a hundred years ago, but for a long time the results found only limited application to oceanographic conditions. The interest in the internal waves increased greatly when it was demonstrated that such waves can occur not only where the density of the liquid changes abruptly, but that they can be found in any liquid in which the density changes continuously with depth. After

this had been shown the observations demonstrated the nearly universal presence of such waves, the study of which has formed a fascinating subject and has attracted a great deal of attention during the last 20 years.

The accelerated study of the short surface waves that are generated by the wind is of even more recent date. In contrast to the subject of internal waves which was greatly broadened by a theoretical advance, the study of the short surface waves has primarily been furthered by means of new techniques of observation which have rendered many new facts that could be arranged systematically by means of the century old theories. This applies not only to the behavior of the waves of the open sea, but also to the modifications to which the waves are subjected when entering into shallow water. When dealing with the latter problems some notable theoretical advance have been made, but on the whole we are still groping for the correct explanations of the generation of the wind waves and for many features of their characteristics. This subject is also one which at present arouses a great deal of interest and within which the near future may bring us new information.

The stepwise expansion of knowledge is more apparent in the field of general physical oceanography that is concerned with the character and history of the water masses of the oceans, the interaction with the atmosphere, the currents of the upper layers of the oceans, and the deep water circulation. During the last century we can recognize three different periods, and at present we are, I believe, at the doorsteps of a fourth. In each period there has been not only an increase in our factual information as to the sea and an expansion of the interpretations of the observed events, but there has also been an expansion of the number of persons engaged in oceanographic studies. Therefore, at each step more and more persons have contributed to the growth of oceanography.

Oceanography first emerged as a separate field of study when nearly a hundred years ago, in 1852, M. F. MAURY published his compilations of ocean surface currents and temperatures, and thus took the first step towards a systematic representation of the surface conditions of the sea. MAURY'S charts and his sailing directions were of the greatest practical value to shipping in the days of the sails, and ships which followed his advice could in many

instances curtail their travel time by weeks. MAURY also organized the systematic collection of ships' observations by means of which the charts and the sailing-directions could be improved, but his influence on the advance of oceanography went much further because he prepared the first comprehensive text on oceanography, "Physical Geography of the Sea" which was published in 1855 and which received a very wide distribution. During the next 20 years at least 15 editions of MAURY's book were printed in U.S.A. or London, several of which contained revisions and expansions. MAURY did not confine himself to an enumeration of the at that time known facts, but he also tried to interpret them. When dealing with the currents he was fully aware of the importance of continuity, and he recognized the polar origin of the cold deep water masses of the oceans, but many of his speculations or conclusions are now mainly of historical interest. Still, the one man, M. F. MAURY, exercised by his initiative and writings a very great influence and contributed greatly to the rapidly increasing interest in the seas of the world. It lies near at hand to assume that, in part, his influence was responsible for the planning of the great enterprise which marks the beginning of the systematic exploration of the deep ocean, the "Challenger" expedition, 1872—76.

MAURY had mainly discussed the observations from the sea surface, because only these were available in numbers. Under the leadership of WYVILLE THOMSON the CHALLENGER expedition opened up a new and fascinating field, the study of the depths of the seas. The biological results were the most spectacular and upset many of the older notions, but the expedition also brought back numerous samples of the bottom sediments upon which until quite recently the general knowledge of the character of the ocean floor in the deep regions was based. It also brought back systematically collected information as to the temperatures and salinities of the waters at different depths and thus information upon which the first comprehensive pictures of the character of the ocean waters could be derived.

The knowledge of the ocean waters did, however, not advance much beyond the descriptive stage, mainly because the theoretical tools for a quantitative analysis had not yet been developed. Great physicists and mathematicians of the 19th century had dealt with the motion of ideal fluids and had solved many of the pro-

blems of classical hydrodynamics, but none had examined the laws of motion applicable to fluids in which the density is not a function of pressure only, nor had the concepts of turbulent motion with all its consequences been introduced. It should also be added that not only the theory was lacking, but the accuracy of the observations of temperature and salinity, and therefore of the density of the waters, was too small to meet the requirements of physicists.

It may, however, be mentioned that, when discussing the results of the Norwegian deep sea expedition, 1876—78, HENRIK MOHN computed the topography of the sea surface, assuming that at a depth of 300 fathoms the isobaric and the level surfaces coincided, and he computed the surface currents assuming that the component of gravity acting along the sloping sea surface was balanced by the Coriolis force. According to our present standard, his results were very inaccurate because they were based on inaccurate values of the densities of the waters, but in principle his method was correct.

The next period in oceanography is represented by the years from around year 1900 until the beginning of the last war. It was a period of rapid expansion, characterized by great improvements in the technique of observations and even more by the fruitful application of physics to the problems of the ocean. It was a period in which new knowledge was rapidly added and during which well-known features were interpreted in the light of new theoretical insight. I will not tire you by a review of familiar advances, but would like to point at some of the highlights of the development.

The density of sea water as function of the three variables, temperature, salinity and pressure was determined with great accuracy and tables were prepared which form some of the indispensable tools in oceanography. Reliable and remarkably accurate deep sea thermometers were designed, the term salinity was defined and methods for very accurate determinations were established. By means of the new techniques the densities of the waters could be determined with such an accuracy that the method proposed by MOHN for the computation of the ocean currents could be used not only for rough approximations, but for detailed examination of the relative currents. The method was rediscovered by HELLAND-HANSEN and SANDSTROM, and was derived from V. BJERKNES' famous theorem of circulation by neglecting the

acceleration term and thus reducing the problem to one of equilibrium of forces, as MOHN had done. During the following decades this method was one of the most powerful tools in oceanography, although it gives information as to relative currents only, and although the question of computing the true currents has not yet been generally solved.

The very success of the application of the method has perhaps hampered the development of oceanography along other lines. The amounts of energy and effort that have been directed towards the compilation of the necessary data and the subsequent computation of the currents have perhaps distracted the attention from the problem of prognosis, prediction.

In all his work V. BJERKNES himself always emphasized that the ultimate goal in geophysical research is the prediction of future events. When dealing with the atmosphere V. BJERKNES used to point out that we know the laws of hydrodynamics and thermodynamics and that we, on the basis of observations, can obtain information as to the conditions in the atmosphere at one given moment, including the field of motion as derived from balloon observations. Theoretically, a computation of the future state of the atmosphere should, therefore, be possible. The actual observations of the field of motion are, however, too incomplete, for which reason it has become necessary to use the geostrophic wind when attacking the problem of prediction, but the problem can be formulated in such a manner that knowledge of the field of pressure from which the geostrophic wind can be derived, has rendered valuable results.

When dealing with the ocean the situation is less favourable. In the first place the task of obtaining any knowledge of the field of motion by means of direct observations is a hopeless one. It could not be accomplished even if all the ships of the world were at disposal and could be anchored all over the seas. In the second place our observations cannot give us complete knowledge of pressure because we do not know the topography of any isobaric surface or the isobars in any level surface. Therefore, we cannot compute the geostrophic current.

When dealing with predictions it is, therefore, necessary to attempt entirely different approaches, but such attempts have been slow in coming. It seems probable that not only the inherent

difficulties of the problem have postponed an attack, but it may also be, as already indicated, that the efforts towards obtaining an approximate knowledge of the currents have distracted from posing the question.

Needless to say, the attention during the nearly 40 years period which I am trying to discuss was not directed exclusively to the study of the large scale currents.

In the field of dynamics great attention has been paid to the turbulence of the motion with all his consequences. The terms turbulence and turbulent motion have been introduced in physics, but actually the consequences of the turbulence were recognized in oceanography at an early date, when EKMAN published his classical paper on the winddriven current and introduced the concept of virtual viscosity, now called eddy viscosity. After the study of turbulence had been taken up in the laboratories the oceanographers have repeatedly received valuable impulses from physics and have been able to use the laboratory results and the theories based upon these for the interpretation of conditions observed in the ocean.

Closely related to the study of mixing processes was the introduction of the concept of water masses and the development of ingenious methods by means of which it became possible to trace water movement over long distances. These methods have been particularly fruitful when dealing with the deep sea currents which are so weak that the standard methods of computation fail. Thus, the numerous expeditions which have visited all parts of the oceans have brought factual information as to the character of the waters, and by means of the different methods of interpretation there has gradually emerged a consistent picture of the life history of the different water masses, and of the processes by which they retain their characteristics.

Many more advances could be recorded, but I shall confine myself to the mentioning of only a few more. The introduction of the echo sounding methods lead to an enormous expansion of our knowledge of the topography of the ocean bottom and to radical changes in our ideas as to the bottom features. During the last years before the war the observations were accumulated much faster than charts could be prepared. The interaction between the ocean and the atmosphere received great attention, and in this

field the problems became more clearly defined. Knowledge of the characteristics of the waters in regard to extinction of light increased fast because of the introduction of improved and accurate instruments. All this activity was reflected in the increased attendance at the meetings of our Association and in the scope of the papers that were read at the meetings.

I mentioned introductory that it seems as if we now are entering a new period in oceanographic research. I believe this to be true because of the many new instruments which recently have been taken into use, because of expansions of theoretical work, and last but not least because during the last years many recruits have entered the field with young eyes, with good training and with enthusiasm for their work.

Of the new instruments the bathythermograph has become indispensable standard equipment by means of which our knowledge of the temperature distribution in the upper layer of the sea has been increased manyfold. An oceanographic cruise without bathythermograph observations is now an impossibility. The equivalent instrument for a continuous record of the variation with depth of salinity or density is still at its experimental stage, but it is probably only a question of time, when this instrument will also become a standard equipment.

Our knowledge of the acoustic properties of the sea has been developed to an undreamed-of degree, and the instruments used in acoustic research have revealed new and unsuspected oceanographic features. I am in the first place thinking of the discovery of the deep scattering layer for which as yet no adequate explanation has been offered.

Equally important is the development of the methods for radio location at sea, the LORAN, SHORAN, DECCA and others. These have found two very important applications to oceanographic work. In the first place they make possible the full use of the echo sounding method for determining the topography of the bottom. Until recently the accuracy of these soundings far exceeded the accuracy with which the location of the sounding could be ascertained, except within sight of shore or in shallow waters where the radio-acoustic method could be employed. Now, one has finally the means of establishing the exact position at which soundings are taken and can thus eliminate the troublesome adjustment of

lines of soundings and the uncertainty that always remains, regardless of how careful the adjustment has been made.

In the second place the method of radio location at sea has proved equally or perhaps even more important to the detailed study of ocean currents and the examinations of the details of the structure of the ocean waters. The introduction of entirely new methods for determining surface currents has opened up a great new field of research, and this in conjunction with the frequent determination of the exact position of the ship has already given us new insight in the structure of the currents off the east coast of the United States. This knowledge will further promote the study of the nature of the turbulence of the sea and particularly of the large scale horizontal mixing. In dealing with the latter the application of the most recent theories of turbulence has rendered very interesting results, and it appears that we are approaching a much better understanding of the physical characteristics of the turbulence.

Not only in this field have important applications of theoretical research been made. The intimate relationship between the circulation of the atmosphere and the ocean which has long been recognized in a qualitative manner has been dealt with quantitatively and results have been obtained which may make possible a new attack on the problem of predicting changes in the ocean currents. There remains much to be done because even such a fundamental factor as the drag of the wind on the sea surface needs to be further examined.

The recently developed methods for obtaining long and undistorted cores of the bottom sediments must also be mentioned. It appears that by the examination of these cores much can be learned about the recent geological history of the earth and about the changes in climate that have taken place during the last several million years. The seismic methods for the examination of the deeper structure of the ocean bed have similarly opened up a new field which may render data of importance to the history of the earth during long geological periods.

Even the atomic age is placing its stamp on the progress in oceanography because the advanced knowledge in that field has rendered new and useful tools. The study of the distribution of carbon isotopes has already started and may further help to clearify

part of the history of the deep waters of the oceans and part of the past history of the earth.

The most promising feature of what has happened during the last decade is perhaps that so many young men have been attracted to oceanography and have made noteworthy contributions. Furthermore, that with the increased number of oceanographic institutions and with the greater facilities for travel and exchange of ideas the training of oceanographers can be made broader and better. I am under the impression that the training of geophysicists in general has improved and that there is a clearer recognition of the fact that physicists and geophysicists need not only different tools, but that they must attack their respective problems in different manners, and that they need a different outlook.

When V. BJERKNES in 1917 gave his entrance lecture as professor of theoretical meteorology at the geophysical institute in Bergen his subject was "Physics and Geophysics". It might be equally appropriate to discuss physicists and geophysicists. In geophysics exact work encounters peculiar difficulties, and is often disappointing and exasperating to the person who always wishes to ask a clear question and who is not satisfied unless he obtains an unqualified answer. In geophysics the problems are often ill defined, and the relationship between different events is often obscured because many factors operate simultaneously. Many events can be adequately described for which reason the descriptive parts of geophysics are voluminous, but the laws governing the events are difficult to recognize. Even if a geophysicist makes a good guess he has often difficulties in finding conditions that are clear-cut enough to substantiate the guess. In contrast the physicist or chemist can formulate an exact hypothesis, can deduce the consequences of his assumptions and can test these consequences by means of controlled experiments. This method of working has much greater appeal to most of those who are capable of dealing with exact problems. Many of these look with some contempt upon the geophysicist who is happy if he can determine the order of magnitude of a coefficient when the physicist requires the 6th decimal place in the corresponding coefficient which occurs in his equations.

When the physicist asks a question his experiments may give him a *yes* or a *no* for answer and that is the kind of answer most

of us would like to get. The geophysicist, on the other hand, who cannot test his hypothesis by experiments has to find his assumptions verified or discarded by watching what happens in nature. He will rarely get a yes or a no in reply and has often to be happy with a may be. Many a physicist cannot get interested in the problems in geophysics, not because of their difficulties, or because of their complexity, but because they cannot be stated precisely and also because an exact solution of a complicated theoretical problem is often of no greater value than a rough interest as compared to approximation because irregular disturbance obscure all finer features. To the geophysicist, on the other hand, the difficulties in asking the question is an added challenge, because of his driving interest in learning how nature works. The geophysicist takes a genuine interest in the surrounding nature, in the ways of the weather, the currents of the sea, the fluctuations of the magnetic needle, the aurora in the sky or the tremblings of the earth's crust. He knows that nature pays no attention to simplicity, but he believes that step by step he can recognize the logic in the happenings. He has to have the patience which is needed for working towards goals that cannot be reached in a life time — if at all.

I mentioned that I am under the impression that the training of geophysicists in general is improved. They receive better tools for future use in their work and broader knowledge of adjacent fields. New instruments place new demands on the ability of the men who shall use them. There is under development a generation of oceanographers who talk a different language from that of my contemporaries, a generation to whom electronic devices are as familiar as the reversing thermometer to us, and to whom the terms of the nuclear physicist are commonplace. It is partly on this basis that I believe we may talk about entering a new epoch in oceanographic research. One may call it an accelerated development, but to me this development contains so many new and startling features, that I believe one may talk about a new trend. Regardless of what term one wishes to apply I am convinced that the developments will make the meetings of our Association increasingly important.

# Reports of Scientific Committees

C 1

## Report of Committee on Tides

By

J. PROUDMAN

*Secretary*

The Secretary is very sorry to report that, for various reasons, the "Bibliography on Tides" remains in the state described in the Report made to the Oslo Assembly (A.I.O.P., Proc. Verb. No. 4, p. 71).

At the request of the Secretary, Dr. GROEN has made proposals bringing the various divisions of the subject matter of the Bibliography into the Universal Decimal Classification. The Committee is considering the advisability of adopting this Classification.

C 2

# Report of Committee on Mean Sea-Level and its Variations

By

R. H. CORKAN

*Secretary*

The mean sea-level data for the ten years 1937 to 1946, inclusive, collected in 1946 and 1947 and referred to in the last report were published in 1950 as Publication Scientifique N°10 of the Association.

Before the war it was the intention of the committee that a pamphlet giving the observed heights of sea-level should be published annually and that every fifth year the printed lists for the preceding five years, together with any lists which had not previously been published, should be bound together and issued as a Publication Scientifique of the Association. A resolution to this effect was unanimously adopted at Washington in 1939 by a Joint Meeting of the Associations of Geodesy, Meteorology, Oceanography and Hydrology.

The Committee now feel, after taking into consideration the rise in the cost of publication and the amount of data which have already been published, that an annual publication is unnecessary, but they recommend that a publication in the same form as Publication Scientifique N°10, at five yearly intervals, should be continued.

By the end of 1951, data covering the five years 1947 to 1951, suitable for inclusion in such a volume, will be available, and a large number of observations for these years have already been received.

The Committee wishes to express its cordial thanks to the International Hydrographic Bureau at Monaco, which carries out the greater part of the work of collecting the data, and to the many national authorities who have actively collaborated in its work.

C 3

# Reports of Committee on the Nomenclature of Ocean Bottom Features

By

J. H. D. WISEMAN
Chairman

In 1948 at the Oslo Assembly a Nomenclature Committee was set up with the following terms of reference "To endeavour to establish, in co-operation with the chart making authorities, mechanisms for the International agreement on nomenclature of submarine topographic features, as well as to consider methods of presentation of topographic data on bathymetric charts".

The members of the committee are: Dr. J. D. H. WISEMAN (Chairman), Vice-Admiral J. D. NARES (Secretary), Prof. H. H. HESS, Dr. K. O. EMERY (U.S.A.), Prof. HANS PETTERSSON (Sweden) and Prof. PH. KUENEN (Holland). In view of the great distances separating the various members, the committee could not function as a working party, nor was it desirable for the committee to make recommendations until the divergent views within the maritime nations were consolidated. It was in consequence desirable to get the interested scientists and representatives of the hydrographic departments to form national groups, so as to consolidate their views, which could then be circulated to other national groups for criticism. Unfortunately it has proved impossible for the International Committee to meet other than at this assembly, though the Chairman was fortunate in arranging a meeting with his secretary, Admiral J. D. NARES in Monaco during July. This meeting proved to be most interesting and instructive. In 1949 three of its members had an informal meeting during the British Association at Newcastle. Contact with the other members has been maintained by correspondance.

At the present Assembly two meetings have been held. Unfortunately both Prof. HESS and Dr. EMERY were unable to leave the U.S.A., but their representatives, Mr. G. LIEFSON (U.S. Navy Hydrographic Dept.) and Dr. R. DIETZ (U.S. Navy Electronics Laboratory, San Diego) were present. A special sub-committee (Dr. WISEMAN (Chairman), Mr. OVEY (secretary), Admiral DAY, Dr. DIETZ, Mr. LIEFSON and Admiral NARES) considered the question of the presentation of topographic information on bathymetric charts.

With the object of consolidating national opinion the International Committee proposed that national groups should be established. Unfortunately both in Holland and in Scandinavia this was not possible. In the U.S.A. a loosely coordinated group consisting of Prof. HESS, Dr. EMERY, Professor SHEPARD, Dr. DIETZ, Dr. FLEMING and the Director of the U.S. Coast and Geodetic Survey was established. In Britain a representative group under chairmanship of Dr. J. D. H. WISEMAN was established. This group included Mr. C. D. OVEY (Secretary), Dr. J. N. CARRUTHERS (Hydrographic Dept.), Dr. L. H. N. COOPER (Plymouth Marine Laboratory), Prof. W. B. R. KING (Dept. of Geology, Cambridge), Mr. J. M. S. MARR and Dr. H. HERDMAN (British National Institute of Oceanography), Lt. Col. R. B. SEYMOUR SEWELL (Zoology Dept., Cambridge), and Prof. J. A. STEERS (Dept. of Geography, Cambridge). This group is an official sub-committee of the Royal Society, and in consequence has enjoyed many advantages.

Many documents and two reports have been issued by the British Committee. These have been circulated to the members of the International Committee as well as to other groups and scientists with a request for constructive criticism. It has always been the policy of the British Committee to welcome constructive criticism, as it was considered that no satisfactory solution to the problems of deep-sea nomenclature would be found unless there is a free interchange of ideas.

In the British Committee's Report / NOB /1(51)—/ definitions have been given to the terms which were considered necessary for the description of submarine topography. It has been the British Committee's endeavour to give logical but simple definitions, to avoid implications about origin, as well as avoiding in the definition any term which has not been previously

defined. The International Committee notes with great satisfaction that there is, in general, agreement about the definitions, but it considers that a few of these terms require improvement. It is therefore satisfactory to report that some of these terms are still under consideration by the interested national groups. It is necessary to quote only a few examples which have been considered by the International Committee. First the term Continental Borderland. There is a general feeling that a more suitable term should be found for the type area off Southern California. Second, the Committee consider that it would be most useful, as well as overcoming some criticism by the U.S. Coast and Geodetic Survey, if an omnibus term was included in the list of definitions for the continental shelf or borderland as well as the slope. Third, the term guyot seems unnecessary in view of the more satisfactory term table mount. Fourth, there is still some need for a general term for an elevation before it can be classified correctly, and the International Committee propose that the term Sea Mount should be used.

In the opinion of the International Committee there is an undoubted case for the systematic development of a new terminology for the secondary features associated with the continental slope, continental borderland, as well as for other deep-sea major elevations. Although it is in agreement with the British Committee that the development of such terminology should follow morphological investigations and not precede them, it is nevertheless of the opinion that a start could be made for the secondary features associated with the continental borderland off Southern California. A small group will be established in Southern California to consider this question, and to make recommendations.

The International Committee consider that any new name or term proposed for a new feature should agree with the general rules of nomenclature and terminology, as proposed by the British Committee. With this end in view they consider it very desirable that any author or chartmaking authority before proposing a new name or term for a feature outside the 100 fm, or 200 m contour should first consult a national group. Although this would invoke some slight loss of independance it would enable author or chart making authority to consider the views of the various national bodies before publication, thus ensuring worldwide consistency, and a more logical development of terminology and nomenclature.

The International Committee consider it desirable that the "Association d'Océanographic Physique" should publish, as soon as the greatest possible measure of agreement has been reached, a brief report. This report should include the lists of the proposed names together with their approximate geographical limits, as well as the definitions of the terms and the general rules of nomenclature and terminology. It is also desirable to include in the report the more important alternatives both for terms and names which have been considered but rejected. In the Committee's opinion charts, giving in outline form the main topographical features and their names, should be included in the report.

*Presentation of Topographic Data on Bathymetric Charts.*

The varying national groups have been unable to make much progress with the latter part of the Committee's terms of reference. Although experts have submitted reports from time to time, little progress has been made, owing to the lack of precision in the terms of reference.

It was, however, considered by the national groups, that the presentation of topographic information could be greatly improved, and with a view of enabling the International Committee to make specific recommendation a small sub-committee was set up to work out proposals. The International Committee has carefully considered its proposals and recommends:

First. That the importance of oceanic depths to geodesists and geophysicists has so increased as to warrant the establishment of a Permanent Bureau with appropriate financial arrangements for the maintenance of world wide bathymetric charts. Consequently it is most strongly recommended that the Association d'Océanographie Physique should submit a resolution to his effect at the closing General Assembly.

Second. That the International Hydrographic Bureau (I.H.B.) should be urged to continue to maintain their bathymetric charts.

Third. That all countries should be urged to provide the International Hydrographic Bureau with as much information as possible on deep-sea soundings.

Fourth. That for general scientific use a scale of 1:10.000.000 at the equator is satisfactory and for detailed charts a scale of

1:1.000.000. So far as the International Hydrographic Bureau is concerned the International Committee see no alternative to the Mercator projection for the extensive equatorial and temperate belts.

Fifth. The International Hydrographic Bureau should be asked to continue its existing practice of correcting soundings wherever possible for the speed of sound in sea-water.

Sixth. Bathymetric charts should be fully contoured with the major contours interpreted by colour layers. Pecked contours should be used when supporting soundings are insufficient. Soundings should be inserted to show maximum and minimum depths. When soundings are sparse a suitable symbol should be inserted to mark their position. The International Committee suggest that the International Hydrographic Bureau should be asked to consider the initiation of this procedure, as they consider that not only would there be a great improvement in the scientific value of their bathymetric charts, but also a considerable saving in printing and other costs. It is also desirable, in the opinion of the International Committee, that copies of the I.H.B.'s plotting sheets with complete soundings should be available for expert use, and that details of surveys of interesting topographic features should be included in the pamphlets issued with the bathymetric charts.

Seventh. The contourer who should be fully skilled in his art, should not be influenced by any preconceived idea that deep-sea topography is similar to that found on land.

Eighth. Internationalily agreed names for the major topographical features should be inserted on all bathymetric charts, as they greatly facilitate scientific discussion. Features which are too small for representation by contours could in some cases be represented with advantage by a symbol, provided international agreement had been reached.

C 4

# Report of the Committee on Oceanographical Observations from Atlantic Weather Ships

By

HÅKON MOSBY

Secretary

All Atlantic Weather Ships have carried out hydrographical and biological investigations as follows.

The programme of the United States' and Canadian ships has included frequent bathythermograph lowerings and some plankton collection.

The programme of the French ships occupying Station K (formerly L) has consisted of the collection of water samples and temperatures at the surface and at depths down to 400 m. Some of the observations have been published in the Bulletin d'Information, Comité Central d'Océanographie et d'Etude des Côtes, Paris.

The Netherlands' ships, which since the rearrangement of stations have shared the occupation of Stations A, T and K, have co-operated in the British programme.

The British ships occupying Stations I and T have made surface salinity and temperature observations daily on station and on passage to and fro. The Netherlands' ships have co-operated in this work when occupying Stations T and K. The data have been used for monthly synoptic charts and are to be published in the Bulletin Hydrographique, Conseil Permanent International pour l'Exploration de la Mer, Copenhagen. Drift bottles have been released at Station T. Experiments have been made with wave recorders. Observations have been made by seismic echo-sounding for the study of submarine geology; the results have been commu-

nicated to this Association by Dr. HILL (F 6.3). Other observations have been made for the study of the inter-relation between sea and air. For plankton studies, vertical hauls with the fine international net have been made from 50 m to the surface, at about weekly intervals. Some of the results have been described in a paper given at the meeting of the Conseil Permanent International pour l' Exploration de la Mer last October. One-litre surface water samples for nanoplankton study have been collected, again at about weekly intervals. These are being discontinued.

Continuous Plankton Recorders have been towed to and from Stations A, I, J, K and M, by co-operation with the Netherlands and Norway. The results appear to be highly promising.

By initiative of Norwegian oceanographers an extensive physical and biological programme has been carried through at Station M, including per week one complete series of observations at the standard depths from surface to bottom at 2500 m and five series to 1 000 m. The biological work was restricted after the first year. A preliminary report has been published (HÅKON MOSBY: Recherches Océanographiques dans la Mer de Norvège à la Station Météorologique M, Cahiers du Centre de Recherches et d'Etudes Océanographiques, Ch. No. 1, Paris 1950). To control the position of the observations, a buoy has been moored in 2 000 m during two months. Drift bottles have been liberated and a few measurements of transparency have been made.

No uniform programme has yet been arranged, but one may evolve from the investigations undertaken by the several countries. Liaison with National Committees has been maintained as occasion required.

C 5

# Report of the Committee on Preparation of a Technical Handbook on Physical Oceanography

By

H. U. SVERDRUP

Chairman

In 1950 section D of the Handbook, "Processing ashore", was completed by Mr. E. C. La Fond, and his manuscript was circulated between the members of the Committee and other interested members of the Association.

The U.S. Hydrographic Office offered to print the manuscript immediately, and this offer was accepted by the Executive Committee of the Association. By this arrangement this section of the handbook will appear as an H. O. publication, but credit will be given the Association for having taken the initiative to have this work done.

The section can be expected to be off the press in September, and can then be bought through the U.S. Hydrographic Office. The Secretary will inform the National Committees as to price and procedure of procurement. Furthermore, the Bureau of the Association requests authorisation to distribute, free of cost, a number of copies to the National Committees corresponding to the categories of the countries.

The other sections are under preparation and it is to be hoped that two or three may be completed before the next General Assembly of the Association. The great pressure of other work of the members of the Committee is responsible for the rather slow progress.

C 6

# Report of the Committee on Bibliography and Classification

By

P. GROEN

*Secretary*

Since the terms of reference of this committee, as established by the Association during the Oslo Assembly in 1948, are to study general questions arising on the preparation of a frequently appearing abstracting bibliography on oceanography and of a classification system of physical oceanography, the present report consists of two parts: 1. Bibliography. 2. Classification.

*Bibliography.*

1. During June 1949 an International Conference on Science Abstracting was held at Paris, under the auspices of UNESCO. The secretary of the present committee attended to this conference on behalf of the U.G.G.I. Of the recommendations of this conference nr. 10 is of special importance to the present committee. It reads:

(10) *Abstracting Journal for Physics*

It is recommended that:

10.1 Consideration be given to the proposal for the publication, under the auspices of a single internationally controlled organization, of a single international general abstracting journal for physics, both pure and applied, including astrophysics and the geophysical sciences, and for such branches of engineering as it may be appropriate to include;

10.2 A committee composed of representatives of the organizations responsible for the existing general abstracting services

in this field, and of the interested international scientific unions be convened to carry this proposal into effect, if it deems it desirable, by such means as giving existing abstracting journals a more international character;

10.3 This committee give attention to the proposals that the abstracts presented in the journal be mixed, some in English, others in French; and that it be in sections which might be published separately, while leaving to the appropriate time the definition of these sections and of the frontier zones for which only selected abstracts would be published.

In view of the inclusion of the geophysical sciences within the scope of these recommendations, it was concluded that the present committee should not take any active step in the matter before it was known what might come out of the efforts made by UNESCO. Now, the latter suggested to ICSU (the International Council of Scientific Unions) that it set up a Joint Commission on Physics Abstracting. ICSU did this at its meeting in September 1949, the U.G.G.I. being included in the Joint Commission. As the representative of U.G.G.I. in this Commission Colonel LACLAVÈRE was appointed by U.G.G.I. The ICSU Joint Commission on Physics Abstracting designated four of its members (the U.G.G.I. representative not being among those four) to represent it on any committee on physics abstracting that UNESCO might establish. In view of the foregoing UNESCO invited the ICSU Joint Commission and the two organizations which publish abstracting journals covering the whole field of physics to form a Committee on Physics Abstracting, which held its first session on 26, 27. September 1950. In this Committee U.G.G.I. (as it has already been said) is not represented. The two abstracting journals meant, are "Science Abstracts and "Bulletin Analytique".

In the meanwhile, the secretary of the present committee has tried to contact the U.G.G.I. representative within the ICSU Joint Commission on Physics Abstracting, in order to know what this Joint Commission, or the UNESCO Committee has done or is planning to do about bibliographical abstracting in the field of the geophysical sciences (including physical oceanography). Up till now, however, these efforts have been without success.

The secretary of the present committee has also tried, but also without success, to contact the President of the „Commissione Talassografico del Consiglio Nazionale delle Ricerche" of Italy, which has undertaken the continuation of the publication of the Bibliographia Oceanographica; the latter is a bibliography, which gives also abstracts, but which does not as yet serve quite the same purpose as the sort of bibliography meant in the terms of reference of the present committee.

*Recommendation.* The present committee should continue to try to establish contact with the agencies that are already concerned with studying or practising publication of abstracting bibliographies in any field which also embraces physical oceanography, the final aim being to get a periodically and frequently appearing abstracting bibliography in physical oceanography, either separate or a part of a bibliography in a wider field.

As soon as it becomes reasonably clear that a solution to the present problem will be found, the committee should prepare a list of all periodic or aperiodic publications which deal exclusively or intermittently with physical oceanographic topics, and should attempt to achieve that all papers are preceded by such an abstract (synopsis) as can directly be used in the abstracting journal. To achieve the said objects, the committee should contact the national committees on oceanography.

2. *Classification.* A first and a revised draft classification scheme of oceanographic topics within the framework of the Universal Decimal Classification has been prepared and distributed among the members of the committee. A copy of the latter one has been attached as an appendix to this report. It should be observed that this draft scheme mentions subject divisions only, but that the U.D.C. provides also for an independent geographical classification. The rather few comments to this draft scheme do not yet make it possible to present to the Association Internationale d'Océanographie Physique a definite proposal concerning the matter.

*Recommendation.* The committee should continue to consider the proposed draft decimal classification scheme (among others by using it experimentally) or any such classification scheme as might seem profitable.

# General Reports

## E 1

## The British National Institute of Oceanography

By

G. E. R. DEACON

British National Institute of Oceanography

The National Institute owes its existence to the growing requirements for detailed and systematic knowledge of the basic processes in the sea, and the feeling that the United Kingdom in co-operation with the Commonwealth Countries, should play a part in keeping with its tradition of interest in the oceans and their navigation. The Institute is to be academic in nature and to have some bias towards physical oceanography; the first annual report has been published (Cambridge University Press 5 s.). The headquarters of the Institute will be near London.

E 1.1

# Trabajos Oceanograficos de la Direction General de Navegacion e Hidrografia

Por

LUIS M. GIMENEZ

Instituto Geografico Militar, Buenos Aires

La importancia práctica y científica de las investigaciones oceanográficas, fué reconocida por nuestra Marina de Guerra desde sus comienzos; pues con claro criterio de lo que ellas significarían para el desarrollo integral de la navegación y de las industrias del mar, nunca escatimó esfuerzos para conocerlo hasta en sus mínimos detalles.

Los primeros trabajos fueron desarrolladas con escasos medios, lo que agregado a la técnica rudimentaria de la época, no permitieron alcanzar resultados de extremada científica. Más tarde, aumentados los recursos e instalados ya en Laboratorio Oceanográfico de la Dirección General, se iniciaron los trabajos estadísticos que permitieron la publicación de las cartas que se describen más adelante.

Las primeras zonas donde se operó en forma orgánica y con un plan científicamente establecido fueron las costas de la Provincia de Buenos Aires y la Costa Norte de Tierra del Fuego.

## CARTA LITOLOGICA.

### No. 15

Esta carta ha sido confeccionada en base a los análisis de fondos marinos, que ha efectuado la Sección Oceanografía. Estos fondos han sido extraídos por buques de nuestra Marina de Guerra,

durante el desarrollo de diversas campañas hidrográficas y oceanográficas.

El método empleado para los análisis es el de Thoulet, adoptado por el Consejo Permanente Internacional de Oceanografía.

Para la clasificación de fango y arenas, se efectuó su estudio granulométricamente y se clasificó macroscopicamente el pedregullo, guijarros, piedras, conchillas, etc., dando los porcentajes según su predominio.

Para determinar los porcientos de $CO_2$ Ca (Calcáreo) se ha convenido en dosar el $CO_2$ (anhídrido carbónico) contenido en las muestras analizadas.

Para la confección de la carta, se han empleado más de 1.300 muestras de fondos marinos, no pudiéndose considerar como definitiva pués se completará a medida que se disponga de nuevas muestras.

## CARTA DE DENSIDAD EN SUPERFICIE.

No. 16

Esta carta representa la densidad del agua de mar en la superficie.

Los valores medios son dadas por determinaciones analíticas de cinco mil muestras de agua de mar analizadas por la Sección Oceanografía.

El método empleado es el de Knudsen adoptado internacionalmente.

Las muestras han sido extraídas por buques de nuestra Marina de Guerra.

## CARTA DE SALINIDAD.

No. 17

Esta carta representa los promedios mensuales de salinidad de los análisis de muestras de agua de mar y son las determinaciones analíticas de cerca de 5.500 muestras.

Dichos estudios han sido efectuados en la superficie del mar epicontinental argentino y mar antártico argentino.

## ISOTERMAS MEDIAS DE SUPERFICIE EN EL MAR.

No. 18 al 30

Estas representan cerca de 100.000 observaciones.

Es dada por valores medios mensuales y trazada por líneas isotermas.

## PLAN OCEANOGRAFICO

No. 31

Para facilitar el estudio se ha dividido en seis regiones y estas en zonas.

### REGION A

Comenzaremos por el desarrollo y estudio a efectuarse en la Región A ó sea la Plataforma Continental; ésta se ha dividido en cinco zonas y a su vez en varias sub-zonas.

*Zona 1:* Dividida en dos sub-zonas 1a) y 1b). — La primera comprende el Río de la Plata hasta la línea de unión del Faro San Antonio hasta Punta del Este en la costa uruguaya. La segunda desde allí hasta la línea de 100 brazas limitando al Norte con la normal en Punta del Este y al Sur con la normal en Faro San Antonio.

*Sub-zona 1a*): Comprende el Río de la Plata, formado por la confluencia de los ríos Paraná y Uruguay.

*Sub-zona 1b*): Esta sub-zona tiene la particularidad de la influencia del Río de la Plata y la línea de unión entre éste y el mar.

*Zona 2*: Dividida en tres sub-zonas.

*Sub-zona 2a*): Comprende el Rincón de Bahía Blanca.

*Sub-zona 2b*): Comprende los golfos San José y San Matías.

*Sub-zona 2c*): Limita al Norte con la zona 1, al Sur, parte del Faro Punta Delgada y entre la costa y la línea de 100 brazas.

*Zona 3:* Está dividida en tres subzonas y comprende desde el límite Sur de la anterior hasta la línea NWSE que nace en Faro Cabo Blanco y desde la costa hasta el limite con la zona 5 dejando afuera la plataforma de 100 brazas y las Islas Malvinas.

*Sub-zona 3a*): Comprende el Golfo Nuevo.

*Sub-zona 3b*): Comprende Golfo San Jorge.

*Sub-zona 3c*): Comprende desde el límite sur de la anterior

hasta la línea NW.SE que nace en el Faro Cabo Blanco y desde la costa hasta el límite con la zona 5 dejando afuera la plataforma de 100 brazas y las Islas Malvinas.

*Zona 4*: Se ha subdividido en tres sub-zonas. Limita al Norte con la zona 3c), siguiendo el límite de la plataforma Continental sin comprender las Islas Malvinas, hasta la Isla de los Estados, Estrecho Le Maire, Canal Beagley límites con Chile.

*Sub-zona 4a*): Comprende los alrededores de la Isla de los Estados.

*Sub-zona 4b*): Abarca el Estrecho Le Maire. Canal Beagle y límites con Chile.

*Sub-zona 4c*): Límita al Norte con la zona 3c), siguiendo el límite de la Plataforma Continental sin comprender las Islas Malvinas, hasta la Isla de los Estados, Estrecho Le Maire, Canal Beagle y límites con Chile.

*Zona 5:* Comprende las Islas Malvinas y alrededores hasta la línea de las 100 brazas.

## REGION B

Esta región comprende la parte de mar situada hasta 200 millas fuera del límite de la Plataforma Continental, desde el paralelo 35° aproximadamente hasta el paralelo 55°.

## REGION C y C'

Comprende el pasaje Drake, la región de las Islas Georgias y Sandwich del Sur, limitadas al Norte por el paralelo 52° 20', meridiano 52°, paralelo 55°, línea de 100 brazas al Sur de Tierra del Fuego; al Este por el meridiano 25°; al Sur por el paralelo 60° y al Oeste por el meridiano 74°.

Esta región está dividida en dos partes, la "C" el Pasaje Drake, y la "$C^1$" las Islas va citadas. La divisoria de estas dos zonas es el meridiano 52°.

## REGION D

Esta región comprende toda la zona Antártida Argentina y sus mareas interiores.

## REGION E

Comprende el Estrecho de Magallanes, los Canales Fueguinos y la parte de la Plataforma Chilena.

## REGION F

Esta Región comprende la parte de la Plataforma Continental, sobre la costa Uruguaya a partir del límite de la Zona 1 de la Region „A".

E 2

# Physical Oceanography in Canada, 1948—51

By

H. B. HACHEY

Chief Oceanographer

Canadian Joint Committee on Oceanography

*Introduction.*

In an earlier communication (HACHEY, 1948), the post war development of physical oceanography in Canada was outlined. This post war development followed the organization of the Canadian Joint Committee on Oceanography, which is presently comprised of representatives of the Fisheries Research Board of Canada, the Royal Canadian Navy, the National Research Council, and the Canadian Hydrographic Service. The Meteorological Service of Canada, while interested in the activities of the Joint Committee, has not as yet taken out active membership.

This Committee, which came into existence in 1946, was set up to further co-operate oceanographic research in Canada, and to direct, through the Chief Oceanographer, the work of the Atlantic and Pacific Oceanographic Groups located respectively at the Atlantic Biological Station at St. Andrews, N. B., and at the Pacific Biological Station at Nanaimo, B. C. The organizational chart is shown in Figure 1.

While the co-operating organizations were cognizant of the many oceanographic problems requiring early attention in the fundamental as well as in the applied fields of oceanographic research, it was visualized that one of the main difficulties to be overcome was the lack of trained personnel in the physical and chemical aspects of the subject. While the main problem still exists, the possibilities for the immediate future are much brighter.

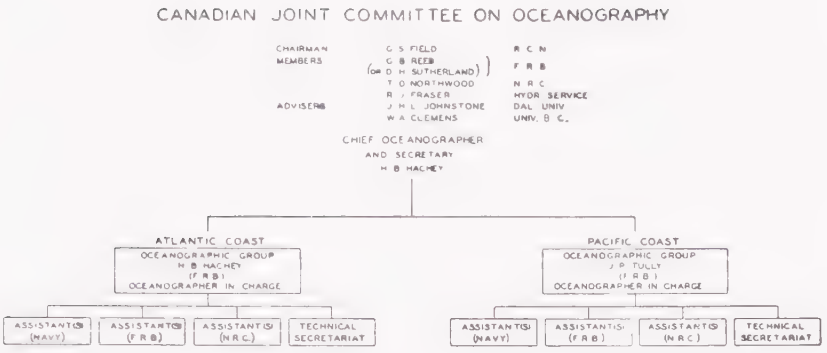


Fig. 1.

Additional qualified personnel, with interests in various phases of oceanography, are gradually becoming available. In particular, the newly established Institute of Oceanography at the University of British Columbia now serves to direct the interests of some students of various faculties towards the problems of the oceans.

The efforts of the Joint Committee on the Atlantic Coast have resulted in large scale co-operative efforts between the Atlantic Oceanographic Group, the Fisheries Research Board, the Naval Research Establishment, the Royal Canadian Navy, and the Canadian Hydrographic Service. On the Pacific Coast, the Pacific Oceanographic Group, the Fisheries Research Board, the Pacific Naval Laboratory, the Royal Canadian Navy, and the Canadian Hydrographic Service have co-operated in extended field programs.

On both Coasts liaison is maintained with United States organizations, prosecuting studies in ocean waters, and co-operative efforts have resulted, involving the Woods Hole Oceanographic Institution, the U.S. Hydrographic Office, the U.S. Fish and Wildlife Service, and the U.S. Navy Electronics Laboratory.

Our northern waters too, are being given some attention, with specific interests at present in the waters of the Labrador Coast, the Hudson Bay, the Beaufort-Sea, and Bering Strait.

*National Committees on Oceanography.*

The Associate Committee of the National Research Council on Geodesy and Geophysics, acts as the National Committee on

Physical Oceanography. This Associate Committee maintains close liaison with the Canadian Joint Committee on Oceanography, which Committee is chiefly an administrative body. Realizing the need of a National Committee to advance the study of oceanography in all its branches, the Royal Society of Canada, in 1950, established a Standing Committee on Oceanography. The purpose of this Committee will be, in general, to advance the study of oceanography in its national and international requirements, to nominate delegates to represent Canada at international oceanographic congresses, to present its findings by means of symposia from time to time, and to submit annual reports of its activities to the Council of the Society.

*Activities of Canadian Organizations in Physical Oceanography, 1948—51.*

The activities of the various Canadian organizations involved in physical oceanography in the three year period reported upon may be summarized as follows:

(a) General oceanography of Canadian Atlantic Waters, involving studies of the characteristics and seasonal changes of the waters of the Bay of Fundy, the Scotian Shelf, the Gulf of St. Lawrence, and the Grand Banks of Newfoundland,

(b) Introductory studies of the fundamentals of "slope water" of the Scotian Shelf,

(c) General oceanography of the waters of the Labrador Current, Hudson Bay, and Strait,

(d) Gulf Stream studies,

(e) Pollution studies in estuaries,

(f) General oceanography of Canadian Pacific waters, involving studies of the characteristics and seasonal changes of the waters of Georgia Strait and offshore areas,

(g) General oceanography of the waters of Bering Sea and Strait,

(h) Fundamental studies on the influence of fresh water in the sea,

(i) Fundamental studies of estuarial problems using model basins,

(j) Problems of sound transmission in the sea,

(k) Tidal and Current studies,
(l) Charting of Canadian coastal areas,
(m) Studies of the interaction between sea and atmosphere.

*Modern Oceanographic Instruments.*

Canadian oceanography has been assisted through the many developments of new instruments, furthered chiefly by the Woods Hole Oceanographic Institution. Among these are the Bathythermograph, the Salinity-Temperature-Depth Recorder, the Geomagnetic Electrokinetograph, and the Sea Sampler, the details of which have been described in various scientific publications. The Woods Hole Oceanographic Institution has been most helpful in furthering the use of such equipment in the Atlantic, Pacific, and northern areas.

*Summary.*

In summary, considerable progress has been made during the period 1948—51, in the expansion of physical oceanography in Canada. In particular, physical oceanography in Canada has been furthered by:

(a) the development of a national interest in the subject,
(b) the co-operation of various national organizations having an interest in the sea,
(c) the training of personnel,
(d) the availability of ships and modern equipment, and
(e) international co-operation between Canadian and United States organizations.

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E 2.1

# Physikalische Ozeanographie in Deutschland 1945—1951

Von

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## 1. *Morphologie und Geologie.*

Eine Bearbeitung von Lotungen wurde für folgende Meeresgebiete vorgenommen: Deutsche Fischereikarten für Nordsee und Barentssee (1). Über Änderungen der Tiefenverteilung in der Deutschen Bucht, die von den Vermessungsschiffen des Deutschen Hydrographischen Instituts beobachtet werden, soll laufend berichtet werden (2). Für das Europäische Nordmeer (Norwegische See) hat Stocks eine neue Tiefenkarte entworfen (3), desgleichen für das Seegebiet der Hawaii-Inseln (4).

Stille stellt eine vergleichende Betrachtung zwischen »Ur- und Neuozeanen« an (5). Eine kritische Betrachtung der grössten Tiefen der Ozeane gibt Wüst (6). Karten der Bodenbedeckung sind von Pratje (7, 8) gegeben worden, der auch über Grundproben aus der Ostsee berichtete (9) (10). Im Bereich der Deutschen Bucht sind Arbeiten ausgeführt worden, die Umlagerung und Materialtransport am Boden erfassen (11) (12) (13) (14). Im Ostseegebiet hat Wirtz (15) die entsprechende Aufgabe behandelt. Die in der östlichen Nordsee beobachteten Steingründe hat Pratje als Endmoränenzüge gedeutet (16) und auf die besonderen geologischen Verhältnisse zwischen Helgoland und der schleswig-holsteinischen Westküste (17) (18) hingewiesen. Jarke (19) gibt einen Vergleich der Sedimentationsverhältnisse in Nord- und Ostsee (Gezeitenmeer und gezeitenfreies Meer) und untersucht den Zusammenhang der Ablagerungsvorgänge mit dem hydrographischen Aufbau (20) (21). Über die Erforschung des Meeresbodens hat Pratje (22) einen

Überblick mit ausführlichem Literaturverzeichnis gegeben. Derselbe Verfasser hat auch Geologie und Morphologie des St. Pauls-Felsen (23) behandelt. Schott (24) gibt die Flächen der Sedimentationstypen im Atlantischen Ozean und Correns (25) untersucht die Bildungsbedingungen der Sedimente. Pratje benutzt bei der Untersuchung des Zusammenhanges zwischen langdauernder Klimaänderung und Sedimentation an Hand des »Meteor«-Materials aus dem Atlantischen Ozean neben den Foraminiferen Kieselorganismen und Korngrössenverteilung. Die bisher unveröffentlichte Arbeit enthält Angaben über die Tiefenlage der während der letzten Eiszeit abgesetzten Schichten im Meeresboden.

### *2. Meeresströmungen.*

Wüst gibt Untersuchungen zum Thema Zirkulation (1) (2) und eine räumliche Darstellung der Bewegungsvorgänge (3). Neumann liefert (4) (5) ebenfalls zum Problem der ozeanischen Zirkulation Beiträge, die Zusammenhänge zwischen dem Geschehen in Atmosphäre und Ozean behandeln. Den äquatorialen Gegenstrom sieht Neumann als Folge des unsymmetrischen Windfeldes zu beiden Seiten des Äquators an (6). Der Golfstrom erhält ebenfalls seine Energie aus dem Windfeld (7). Model (8) zeigt, dass die durch die Floridastrasse nach Norden strömende Wassermenge ebenso gross ist, wie die in das Amerikanische Mittelmeer einströmende Wassermenge. Das subtropische Konvergenzgebiet im Südatlantischen Ozean (9) und die kartographische Darstellung der Oberflächenströmungen (10) hat Schumacher behandelt.

Von Hansen (11) werden die hydrodynamischen Unterlagen zur Ermittlung von Triftstrom und Windstau aus dem als bekannt vorausgesetzten Windfeld unter Benutzung der Tiefenverteilung für schmale Kanäle und für zweidimensional ausgedehnte Meeresgebiete gegeben. In einem schmalen Modellkanal sind Stau und Strömung in Abhängigkeit von der Windgeschwindigkeit gemessen worden (12). Für den Teil des Atlantischen Ozeans, der durch die Küste und durch die Breitenkreise 40° Nord und 30° Süd begrenzt wird, ist aus dem bekannten Windfeld für den Monat August Strömung und Gestalt der Wasseroberfläche nach dem Randwertverfahren berechnet worden. Die Ergebnisse stimmen mit den aus Besteckversetzungen abgeleiteten Strömungen überein

(13). In einer weiteren Untersuchung ist gezeigt, dass die Vertikalkomponente der Stromgeschwindigkeit bei Bewegungen in begrenzten Meeresgebieten nicht vernachlässigt werden darf (14).

Den Einfluss des Windes auf den Wasserstand in der Deutschen Bucht hat Tomczak (15) am Beispiel einer Sturmflut behandelt. Die Oberflächenbeobachtungen der Deutschen Antarktischen Expedition »Schwabenland« 1938/39 (16) (Model-Ritscher) wurden von Model mit älteren Beobachtungen verglichen und die Frage diskutiert, ob die Unterschiede auf Beobachtungsfehler oder Klimaänderungen zurückzuführen sind. Dietrich (17) setzt die Verteilung der Anomalien im thermohalinen Aufbau der Ozeane in Beziehung zu der Anordnung der Kontinente. Die sowohl für ozeanographische ebenso wie für allgemein geophysikalische Betrachtungen wichtige Frage nach der Abweichung des mittleren Wasserstandes von der Niveaufläche wurde am Beispiel der Ostsee von Gaye (18) und Model (19) diskutiert.

Eine kritische Betrachtung der Temperaturbeobachtungen vom fahrenden Schiff aus gibt Dietrich (20). Die Oberflächentemperaturen in Nord- und Ostsee sind zu Monatskarten verarbeitet worden (21). Der jährliche Gang der hydrographischen Elemente in Nord- und Ostsee ist allgemein von Dietrich (22), speziell bei den Feuerschiffen »Fehmarnbelt« und »Adlergrund« von Goedecke behandelt worden. Vom gleichen Verfasser sind der dynamische Aufbau und die Strömungen sowie die Verteilung von Temperatur, Salzgehalt und Dichte in der südlichen Nordsee und in der Deutschen Bucht bearbeitet, aber bisher ebenfalls noch nicht veröffentlicht worden. Walther (23) betrachtet die Strömungen in unmittelbarer Nähe der ostfriesischen Küste.

### 3. *Grenzfläche Luft-Wasser.*

Die Grenzfläche Luft-Wasser spielt für die Vorgänge im Ozean, da durch diese hindurch der Energieaustausch stattfindet, eine entscheidende Rolle. Model (1) behandelt den Wärmehaushalt des Meeres und zeigt, dass der Wärmebedarf für das bevorzugte Klima Europas advektiv durch Zustrom in den oberen Schichten aus dem Südatlantik gedeckt wird. Wüst (2) gibt neue Zonenwerte für relative Feuchte und Niederschlag im Atlantik. Neumann (3) (4) (5) behandelt die effektive Schubkraft des Windes, die Rau-

higkeit der Meeresoberfläche und die Windgeschwindigkeit in vertikaler Richtung über den Wellen. Eingehende Messungen des vertikalen Windprofils sind von Roll (6) (7) (8) (9) (10) ausgeführt und behandelt worden. Er hält einen Übergang von laminaren zu turbulenten Vorgängen bei 6.7 m/sec Windgeschwindigkeit in 10 m Höhe für wahrscheinlich. Roll findet seine Beobachtungen (11) (12) über den Zusammenhang zwischen Wellengrösse und Laufstrecke im grossen in Übereinstimmung mit Sverdrup—Munk. Temperaturverteilung und Differenz Wasser-Luft werden vom gleichen Verfasser behandelt (13) (14) (15). Neumann (16) (17) leitet für die Entstehung der Initialwellen als untere Grenze der Windgeschwindigkeit 0.70 m/sec ab. Weiterhin benutzt er eine empirische Beziehung für die Schubkraft des Windes und untersucht das Anwachsen der Wellen längs der Windbahn, den Einfluss der Dauer der Windeinwirkung, sowie Turbulenz und Energiedissipation im Seegang (18) (19) (20). Schumacher berichtet über Wellenaufnahmen (21).

4. Zum Thema *Turbulenzbewegung im Meere*

sind verschiedene Arbeiten im Gange, aber noch nicht abgeschlossen.

5. *Periodische Bewegungen:*

Gezeiten und Eigenschwingungen

Die Untersuchungen über die Ermittlung der Gezeiten in beliebig gestalteten Meeresgebieten sind mit der Entwicklung des Randwertverfahrens methodisch zu einem vorläufigen Abschluss gebracht: Es wurden u.a. behandelt Nordsee (1) (2), Kanal (3), Atlantischer Ozean (4). Unveröffentlicht sind Arbeiten über die Gezeiten in seichten Gewässern, die eine sehr gute Übereinstimmung zwischen Rechnung und Beobachtung geliefert haben. Dietrich (5) behandelt die Einflüsse der Gezeitenstrommischung auf die ozeanographischen und klimatischen Verhältnisse am Beispiel des Englischen Kanals. Die Geschwindigkeitsverteilung der Gezeitenströme in vertikaler Richtung ist im Zusammenhang mit Reibung und Turbulenz untersucht, aber noch nicht veröffentlicht.

Zur Weiterentwicklung und Vervollständigung der Hilfsmittel zur Vorausberechnung der Gezeiten wurden folgende Arbeiten

ausgeführt: Horn (6) hat eine strenge Formulierung des harmonischen Verfahrens als Anwendung 6-dimensionaler Fourier-Entwicklungen gegeben, die auch im Falle nicht-linearer Differentialgleichungen, also bei Seichtwasser- und Flussgezeiten, gültig bleiben. Harmonische Reihen mit 45 Gliedern, die bei halbtägiger Gezeitenform die Hoch- und Niedrigwasser unmittelbar darstellen, sind beim Deutschen Hydrographischen Institut durch Ausgleichung 19-jähriger Beobachtungen nach der Methode der kleinsten Quadrate berechnet worden. Die Darstellungsgenauigkeit bei 28 Gliedern ist merklich höher als bei den bisherigen Verfahren.

Die grosse deutsche Gezeitenrechenmaschine mit 62 Tiden (7) (nach Angaben von Rauschelbach 1938 gebaut) konnte im Jahre 1948 beim Deutschen Hydrographischen Institut wieder aufgestellt und in Betrieb genommen werden. Ferner werden z.Zt. nach einem von Rauschelbach entwickelten verbesserten Verfahren zur harmonischen Analyse der Gezeiten mittels Lochkartenmaschinen, das die Bestimmung von 65 Tiden aus stündlichen Beobachtungen von 369-tägiger Dauer vorsieht, etwa 70 Jahresreihen deutscher und ausländischer Gezeitenbeobachtungen analysiert.

Die Eigenschwingungen homogener und geschichteter Wassermassen lassen sich gleichfalls mit Hilfe des Randwertverfahrens für beliebig gestaltete Meeresgebiete ermitteln. Neumann führt den Impedanzbegriff in die Theorie der Seespiegelschwankungen ein und gibt eine Mündungskorrektur für frei schwingende Meeresbuchten (8) (9). Desgleichen gibt Neumann unter Verwendung des Zusammenhangs zwischen vertikalem Dichtegradienten und der Periode der internen zellularen Eigenschwingungen eine Betrachtung über die von Kalle angestellten Beobachtungen über die innere thermische Unruhe (10) und über die Dichteabnahme mit der Tiefe in den oberflächennahen Schichten des Ozeans (11). Hansen zeigt, dass es Trägheitsschwingungen im eigentlichen Sinne in abgeschlossenen Meeresgebieten mit homogenem Wasser nicht gibt (12).

### 6. *Ozeanographische Beobachtungen und Instrumente.*

Die ozeanographische Beobachtungstätigkeit auf See ist wieder in Gang gekommen, ausser den laufend beobachtenden Feuer-

schiffen konnten Fahrten mit dem Vermessungsschiff »Paul Beneke« und mit dem Vermessungs- und Forschungsschiff »Gauss« in die Nordsee durchgeführt werden, über die zu gegebener Zeit berichtet wird. In unmittelbarer Küstennähe sowie im Gezeitenbereich der Flüsse an der deutschen Nordseeküste sind zahlreiche Untersuchungen über den Wasserstand, die Strömungen, die hydrographischen Elemente und über die Sandwanderung ausgeführt worden.

Einen Überblick über die neueren deutschen meereskundlichen Messgeräte (Wasserstands- und Seegangsmessgeräte, Strommesser, Temperatur-Salzgehalts- und Durchsichtigkeitsmessgeräte usw. gibt Joseph (1). Vom gleichen Verfasser wurde die Frage der quantitativen Durchsichtigkeitsmessungen im sichtbaren und ultravioletten Spektralbereich (2) sowie die Genauigkeit der Tageslichtmessungen im Meere, insbesondere die Effekte der Schwerpunktsverschiebung behandelt (3).

### 7. *Physik und Chemie des Meeres.*

Joseph hat an Beispielen gezeigt, dass optische Werte ebenso wie Salzgehalt und Temperatur zur Charakterisierung von Wassermassen geeignet sind (1). Die Messmethoden konnten so weit vervollkommnet werden, dass für verschiedene Spektralbereiche eine kontinuierliche und praktisch trägheitslose Registrierung der Durchlässigkeitswerte erhalten wird (2). Diese Registrierungen geben einen Einblick in den optischen und darüber hinaus in den hydrographischen Feinaufbau im Meere. Auf Grund des theoretischen Zusammenhangs zwischen Tageslichtmessungen, die den »Vertikalen Extinktionskoeffizienten« und die »Diffuse Reflexion« liefern, und Durchsichtigkeitsmessungen, die den »Physikalischen Extinktionskoeffizienten« ergeben, lassen sich die Absorptions- sowie Vor- und Rückwärtskoeffizienten, aus denen sich der Extinktionskoeffizient des Meerwassers zusammensetzt, bestimmen (3).

Die chemischen und physikalischen Eigenschaften des Meerwassers sind in Form einer Übersicht von Kalle (4) behandelt. Derselbe Verfasser gibt zwei Beiträge zur Produktionskraft des Meeres (5) (6). Den Einfluss einer grossräumigen Umschichtung der Wassermassen im Gotlandbecken auf die Lebensbedingungen untersuchen Kalle und Meyer (7). An einem Beispiel zeigt Kalle

(8) den Zusammenhang zwischen Fischerei-ertrag und vertikaler Dichteverteilung. Krey berichtet über die Bedeutung des Planktons für den Chemismus und die Produktionskraft (9) und über die Zusammensetzung der im Meere suspendierten Teilchen (10), Pratje (11) äusserte sich über die Bedeutung des Meeresbodens als Lebensgrundlage. Im Bottnischen und Finnischen Meerbusen ist der Aussüssungsvorgang an Hand von Beobachtungen über Fluoreszenz und Gelbstoff untersucht worden (12). An methodischen Vorschlägen zur Bearbeitung meereschemischer Proben liegen vor: Kolorimetrische Bestimmung von Silikat, Phosphor und Stickstoff (13), Vereinfachung der Chlortitration (14) und Mikrobestimmung des Chlorophylls (15) sowie eine quantitative Bestimmung des Planktons (16).

## 8. *Meereis.*

Das Ausmass der Vereisung ausgewählter Meeresgebiete, vornehmlich der deutschen Küstengewässer, ist in folgenden Arbeiten behandelt: Büdel (1) und Nusser (2) (3) (4) behandeln die Eisverhältnisse an den deutschen Küsten in den Jahren 1945 bis 1950. Nusser (5) führt den Begriff »Eisvorbereitungszeit« ein und zeigt, dass eine Vorhersage des Beginns der Vereisung möglich ist, wenn die meteorologischen Daten bekannt sind. Prahm (6) gibt eine analoge Untersuchung über die »Abschmelzzeit«. Für einen charakteristischen Fjord Spitzbergens schildert Nusser (7) den jahreszeitlichen Gang der Vereisung an Hand eigener Beobachtungen. Unter Benutzung umfangreicher neuerer Beobachtungen wurden Karten der Eisverhältnisse des Nordatlantischen Ozeans, der Arktis und der Antarktis zu einem Atlas zusammengestellt (8).

Folgenden Herren ist der Verfasser zu Dank verpflichtet, da sie ihn durch Zusammenstellung von Arbeiten aus ihren Spezialgebieten bei der Abfassung des vorliegenden Berichtes unterstützt haben:

Dietrich, Gaye, Horn, Joseph, Kalle, Lüneburg, Model, Neumann, Nusser, Pratje, Roll, Stocks.

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E 2.2

# Report of the Work Carried out by the International Hydrographic Bureau

By

J. D. NARES

International Hydrographic Bureau

Since I last had the honour of addressing the Association of Physical Oceanography at Oslo in August 1948 the following progress has been made in the work carried out by the INTERNATIONAL HYDROGRAPHIC BUREAU of special interest to the Association:

## (a) GENERAL BATHYMETRIC CHART OF THE OCEANS

A new edition of Sheet $A_{II}$ "Eastern Pacific from the Equator to Lat: 46° 40' North and between 90° and 180° West was issued in May 1949. This necessitated the careful scrutiny and plotting onto the working sheets of 37,835 soundings, of which 5,153 have been selected for the published sheet. The previous edition of this sheet, dated May 1912 contained 1,681 selected soundings only. The setting up of the plates and the printing of this sheet was undertaken by the Institut Géographique National of Paris under conditions particularly favourable to the International Hydrographic Bureau, and they are now preparing the new edition of Sheet $A'_{II}$ immediately to the Southward which is expected to be ready for issue by the end of this year.

The work on the revision of sheet $B'_{I}$ between South America and the Antarctic continent and extending from the meridian of Greenwich to 90° West is nearly completed and will be sent to Paris as soon as sheet $A'_{II}$ is finished.

The two sheets comprising the Northern part of the Pacific between Latitudes 46° 40' and 72° North are also under revision.

Financial help towards the preparation of the 3rd Edition of the Bathymetric Chart has kindly been given by the National Academy of Sciences, Washington (Marsh Fund), by the "Challenger Society" of London and by the "Office de la Recherche Scientifique Outre-Mer, Paris".

## (b) NOMENCLATURE OF OCEAN BOTTOM FEATURES

The International Hydrographic Bureau has continued its close collaboration with the Committee on Nomenclature of Ocean-Bottom Features, of which I have the honour of being Secretary. A seperate report on this Committee's work is being presented.

## (c) LIMITS OF OCEANS AND SEAS

A provinsional 3rd Edition of the Bureau's Special Publication No 23 "Limits of Oceans and Seas" was issued in September 1950.

The limits proposed in this new edition have been drawn up after correspondence with the Hydrographers of the various Countries concerned and with certain Oceanographers, it is therefore hoped that, although as stated in the Preface they are mainly for the convenience of National Hydrographic Offices, they will also be acceptable to other interested Authorities.

This Third Edition has been marked "Provisional" as the Directing Committee intend to present it to the Delegates at the VIth International Hydrographic Conference, which opens next April, for discussion and, it is hoped, adoption.

Copies of this Provisional 3rd Edition are being circulated herewith.

## (d) MEAN SEA-LEVEL AND ITS VARIATIONS

The International Hydrographic Bureau has continued the work of collecting data on the observed heights of sea-level and has furnished them to the "Committee on Mean Sea-Level and its variations" of which I have the honour to be Chairman.

A separate Report on the work of this Committee is being presented.

(e) TIDAL HARMONIC CONSTANTS

The "List of Harmonic Constants" published in I.H.B. Special Publication No 26 has been augmented since my report in 1948 by information concerning 320 additional ports and corrections for that previouslys applied for 128 ports.

(f) WORLD NETWORK OF TIDAL AND TIDAL STREAM STATIONS

The necessity of extending the net work of tidal observation Stations was emphasized at the Vth International Hydrographic Conference and a Resolution was passed by that Conference to the effect that increased attention should be given to the need for additional observations on tides and tidal streams in many areas not adequately examined.

Ten general areas where the existing data was inadequate were prescribed in a Circular-Letter sent to States Members and Non Member States by the International Hydrographic Bureau.

Data has since been published by the Bureau covering 40 additional Stations in these designated areas and many additional Stations have also been established in these areas from which the data has not yet been received for publication. A chart showing the world coverage in 1948 in Red and the additional stations in Blue is being circulated herewith.

(g) HYDROGRAPHIC DICTIONARY

The work of compiling a second edition of I.H.B. Special Publication No 32 "Hydrographic Dictionary", the first edition of which was issued in 1946, has now been completed and it is expected to be ready for issuing towards the end of the current year.

The second edition contains 1068 terms in 12 separate languages as against 831 and 9 respectively in the first edition.

## (h) MANUAL OF SYMBOLS AND GLOSSARY OF NAUTICAL TERMS

A revised and considerably enlarged new edition of I.H.B. Special Publication No 22 "Manual of Symbols and Glossary of Nautical Terms and Abbreviations shown on Charts" is about to be issued. This publication now embraces 819 symbols and/or hydrographic terms as well as their abbreviations and where necessary the transliteration used on the charts of 22 different Countries.

E 2.3

# Note on Oceanographic Work in India

By

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Central Board of Geophysics, India

The Government of India have set up a Central Board of Geophysics for co-ordinating the existing resources of the scientific departments and universities in geophysics for research, field work, and training of personnel. Under this Board, a committee has been constituted to prepare plans for the development of oceanography. This Committee has been considering the various aspects of the problems, more especially connected with the starting of an Institute for Oceanographic studies.

During the past, the hydrographic work relating to Indian waters had been in the hands of the Royal Indian Marine and considerable work had been done by the Marine Survey Ship "Investigator" both in respect of physical oceanography and marine biology. The John Murray expedition during 1933—34 by the British Admirality, collected valuable information regarding the topography and deep sea conditions in the Indian Ocean. The results of these geographic and oceanographic studies in the Indian waters have been summarised in the various papers by Col. R.B.S. Sewell. Several expeditions have crossed the Indian ocean and added to our knowledge of the sea. Quite recently during April 1951 the Danish Expedition vessel "HMS Galathea" collected a good deal of data in the Arabian Sea, the Indian Ocean and the Bay of Bengal. One Indian Marine Biologist Dr. R. Prasad had also joined the expedition ship during the operation in Indian waters. At present almost all the work done in India is mostly related to biological work with special emphasis on Fishery. Some aspects of physical oceanography is being studied at present in

the Andhra University at Waltair (17° 42' 23" N; 83° 17' 44" E), where the subject is taught as a special course in meteorology. The Survey of India (Geodetic Branch) have been regularly taking tidal observations and they have also installed several tide gauges quite recently. The Marine Survey Ship of the Indian Navy, of course, continues to carry out some work connected with physical oceanography. The Central Marine Fisheries Research Station at Mandapam (9° 16' 50" N; 79° 8' 30" E) is mostly concerned with the development of fisheries, but some of the broader aspects of the physical oceanography related to fisheries are also receiving attention. The fluctuations in the nutrient salts, oxygen, salinity, temperature variations, etc. in the inshore waters, bacteriological flora, and their role in the food chain of the sea; qualitative and semi-quantitative study of phyto- and zoo-plankton, their distribution, variations in time and space, bottom fauna etc. are some of the more important problems receiving attention at Mandapam. The University of Travancore at Trivandrum (8° 28' 50" N; 76° 55' 30" E) has a marine biological and fisheries laboratory. The Fisheries Departments of Madras and Bombay have been carrying out some marine biological studies.

There have been in the past many recommendations and schemes regarding oceanography in Indian waters. In 1946 UNESCO's subcommission of natural sciences directed that the possibility of founding oceanographical and fisheries laboratory for Indian ocean should be explored. In 1947 the International Commission on Oceanography recommended that a combined oceanographic and marine biological laboratory should be established in the Indian Ocean. During 1949 the Indo-Pacific Fisheries Council of the F.A.O. discussed the preparation of co-ordinated scheme of oceanographic research for the South-East Asia as a whole. The Government of India are also examining a scheme for establishing a fisheries and marine biological station in the Andamans where oceanographic researches could also be carried out.

The main problems confronting the further developments of oceanographic studies in India are lack of research vessel, apparatus and equipment, and experienced scientific personnel for work in the sea. The Oceanography Committee of the Central Board of Geophysics, having carefully considered the present state of work carried on in the different institutions and the nature of

equipment and staff available at each of the centre, have recommended that a Special Officer should be appointed to work out the details for the establishment of a Central Institute of Oceanography at some suitable centre.

E 3

# Greek National Report on Physical Oceanography

By

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and

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## MONTHLY AND ANNUAL MEAN HEIGHTS OF SEA-LEVEL

are presented from the stations Piraièvs, Preveza, Posidhonia, Kalamai, Volos, Thessaloniki, Khios and Kavalla for the years 1937—1940; from Piraièvs and Kavalla also for 1951.

## MARITIME RESEARCHES IN THE AEGEAN SEA

During the last years 1945—1950, the Hellenic Hydrobiological Institute undertook several oceanographic researches in the Aegean Sea. The purpose of these researches was to allow the a/m Institute to prepare an issue of hydrological charts of the Aegean Sea and especially of its northern areas, based on observations made throughout a long period of time. These observations proved that the influence of the surface currents running in and out the Dardanelles straits as well as from the estuaries of Northern Greece is not the same all over the Aegean Sea, sometimes arriving to a minimum. It was lately noticed that, besides their annual variation, there took place a continuous diminution of the influence of the less salinous water and a push forward of the more salinous one a fact that is evidently the result of the influence of the waters of the Eastern Mediterranean on account of their general circulation in that area. And thus, while formerly, the so called equal salinity surface

lines of $39^0/_{00}$ would hardly reach during Summer time the line Cyclades-Lesvos, now it is pushed forward up to the area of Mount Athos-Sporades islands-Gulf of Saronikos-North Peloponnese (Morea). The zone more easterly to the a/m with salinity $37^0/_{00}$ and on a smaller area $36^0/_{00}$, similarly underwent some influence of the more salinous waters as the zone of $33^0/_{00}$—$35^0/_{00}$ was reduced to a minimum. At the same time, the central area of Cyclades shows an augmentation in its salinity, extending beyond the limit of $39{,}2\ ^0/_{00}$.

There is no doubt that these phenomena are associated with some more extended climatological variations or changes, being given that a certain kind of fishes move from the more salinous areas of the Aegean Sea to the Northern part of it. There is also no doubt that hydrological changes cause biological ones.

At the same time researches are taking place with the purpose to determine the nutrient salts of the waters nearby the estuaries of the Aegean Sea since our ship "ALCYONI" confirmed the quantity of nutrient salts in the central Aegean Sea to be poor. The here presented tables contain the hydrological data which have been obtained till to-day. Our hydrological researches continue and we gradually extend them towards the Crete-island and the Ionian Sea. Unfortunately we are not in position to hope that our work will be completed in the immediate future as the Hellenic Hydrobiological Institute gives priority to works of a more practical nature.

## MARITIME RESEARCHES IN THE GULF OF EUBOEA

It is well known that the hydrological behaviour of the Aegean Sea waters is influenced from one side by the geographical form of figure of this area and from the other by the affluxion of masses of water from some other areas. As a result, this hydrological behaviour differs accordingly with the different areas, but, in any case, submitted and obeying to some general rules. Especially several second-order sites of the Gulf, have a different hydrology which causes remarquable biological consequences. Amongst these parts of the water areas, the Gulf of Euboea or Chalcis -gulf is a very predominating one. During 1947—1949 maritime researches

and observations took place, with the result of an actually perfect knowledge of the hydrology of the said Gulf.

The northern part of the gulf is separated from the rest of the Aegean Sea by the shallow waters of Chalcis and those of the Oreos channel. Thus, after the winter equal temperature season, a stable situation is created which remains undisturbed by the circulation of the Aegean Sea's deeper circulating water, as this one knocks itself against the a/m sites of shallow waters. The hydrological conditions inside the gulf at the northern part of it, is fully self-sufficient and independent with the exception only of the surface waters. This condition is evident during Spring-time and the summer months thanks to the distribution of the temperature and salineness of the sea water. After the winter equal-temperature season, the temperature of the water changes only at the waters surface and is apt to adapt its self to the meteorological conditions, while the deeper water zones maintain their low winter degree of temperature. Station No 51 (In Lat. 38° 48' 50" and Long. 23° 08' 10") shows quite clearly this condition.

| Depths in fathoms. | Temperature °C |
|---|---|
| 0 | 23,9 |
| 25 | 14,7 |
| 50 | 12,1 |
| 100 | 11,6 |
| 150 | 11,6 |
| 200 | 11,6 |

During three consecutive years we noticed the same fact at different sections thus resulting that after the somewhat high temperature of the surface and an intermediate one at the zone of 20—30 fathoms, all the remaining mass of water but deeper ones have a low temperature. Outside the Gulf and the adjacent seas the temperature is about 13,3 and 14,2° C.

An analogous phenomenon was noticed in regard with the salinity of the waters and thus, while the surface salinity inside and outside the gulf is the same, the salinity of the deeper zones differs, because these deeper zones of the Aegean Sea knock themselves against the shallow water parts of the Oreos channel and cannot consequently enter the Euboean Gulf which thus retains

in its deeper zones less salinous water and in consequence retains its winter equal salinity state. Sometimes it happens — on account of some metereological condition i.e. strong northerly winds etc. — quantities of salinous water to be forced towards the Oreos channel and flow into the northern part of the Gulf of Euboea. Then these waters dip into the lower zones but this phenomenon has not been noticed to happen every year.

The hydrological independance of these waters is proved also by the conditions of the oxygen distribution in the water; thus, while the oxygen in the upper water zones is abundant until a depth of 50 fathoms its quantity starts to decrease and to diminish to 5,85 mg/l, at 100 fathoms is 4,06 mg/l, at 150 3,50 mg/l and at a depth of 200 fathoms it becomes equal to 1,6 mg/l. At the open area of the Aegean Sea such a lack or penary of oxygen is something quite unknown.

E 4

Report on oceanographical work done by the Directie Benedenrivieren, Rijkswaterstaat, Den Haag, Netherlands:

# Continuous Measurements of Currents and Suspended Material on the Netherlands Light Vessels

By

J. VAN VEEN

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Before 1940 there were 4 light vessels along the Netherlands coast, namely:

"Noord Hinder" (51° 35' N, 2° 37' E).

"Maas" (52° 01' N, 3° 54' E).

"Haaks" (52° 58' N, 4° 18' E).

"Terschellinger Bank" (53° 27' N, 4° 52' E).

On 23rd June 1937 continuous current measurements were started on board the L. V. "Maas", on 24th Feb. 1938 on board the "Noord Hinder" and the "Haaks", and on 9th June on board the "Terschellinger Bank". Because of war circumstances the measurements were stopped on the first three light vessels on 3rd Nov. 1939, on the last one on 6th May 1940.

After the war 3 light vessels were laid out, namely:

"Goeree" (51° 52' 30" N, 3° 38' 45" E, until 13-4-1950; from then: 3° 34' 50" E).

"Texel" (53° 05' 00" N, 4° 31' 32" E).

"Terschellinger Bank" (53° 28' 43" N, 5° 08' 21" E).

Measurements were started again on 8th Feb. 1946 by the "Goeree", on 1st April 1947 by the "Texel", on 9th December 1948 by the "Terschellinger Bank".

These measurements are carried out by means of the Carruthers

vertical log. The counting dial is read every half hour. The depth of measuring was before 1940 always 10 m. After the war three different depths were taken, which are changed every three months, namely 6,8 and 10 m.

The results were worked out into graphs, which show the currents measured as well as their vector-sums over every tidal period and also the prevailing winds. The daily averages of the directions of the flood and ebb currents, as well as the net water transport over a tidal period, vary greatly from day to day, in strong dependence on the wind.

During the last years measurements of the suspended material content of the sea water are also carried out, by means of a Canter-Cremers suspension sampler. At each turning of the tide the material catched by the apparatus is collected. During storms the water appears to carry much more suspended material than during calm weather.

E 4.1

# Les Projects en Oceanographie du Conceil Indo Pacifique des Pêches (FAO)

Par

R. SERENE
Vice-president du C.I.P.P.

Le Conseil Indo Pacifique des Pêches dont le secrétariat permanent est installé à Bangkok (Thailand) a été créé en 1948 à Baguio (Philippines) par les soins de l'Organisation pour l'Alimentation et l'Agriculture (Food Agriculture Organisation, FAO), branche de l'O.N.U. Le conseil réunit les pays de la zone Indo Pacifique, particulièrement du Sud Est Asiatique, dans le but d'organiser une collaboration de travail entre leurs Scientistes et techniciens des pêches pour promouvoir un plus grand développement de la pêche, une meilleure utilisation de ses produits et le cas échèant une protection de ses ressources. Il comprent Australie, Birmanie, Chine, Ceylon, Cambodge, Etats Unies, France, Inde, Indonésie, Hollande, Pakistan, Phillipines, Royaume Uni, Thailand, Viet Nam. Il est organisé en deux Comités, l'un traitant des questions scientifiques, l'autre des questions techniques. Le Comité Scientifique parmi ses nombreux sous-comités comporte un Comité d'Hydrologie dont les projets particulièrement dans le branche marine intéressent l'A.I.O.P. Parmi ces projects il convient de signaler:

1° l'établissement d'un manuel d'océanographie à l'usage des Océanographes travaillant dans le cadre du programme du C.I.P.P.

2° la préparation et la publication régulière, chaque année, d'une bibliographie intéressant l'océanographie de la Zone géographique correspondant au C.I.P.P.

3° la publication pour la zone du C.I.P.P., et qui est limitée en latitude entre le 25° N et 20° S et en longitude entre 60° E et 150° E., de cartes mensuelles des temperatures et salinités de surface comportant également des indications sur les courants et les vents. La réalisation de ce dernier projet s'appuie d'une part sur l'organisation par les soins des États membres d'un vaste réseau de postes d'observations en utilisant les possibilités offertes par les bateaux de commerce qui parcourent la région, de manière à laisser le moins de lacunes possibles aux observations dans le temps comme dans l'espace; d'autre part sur la centralisation des résultats des observations, qui seront confiés à un organisme spécialisé, qui établira et publiera les cartes. Le récent travail de M. Ch. VEEN sur les Salinités de surface dans l'Archipel Indonésien[1] qui est communiqué à cette Assemblée par l'Indonésie, illustre bien un des aspects de la réalisation de ces projects.

[1] Surfaces Salinities in the Indonesian Archipelago and Adjacent Waters. P. CH. VEEN. — O.S.R. Publication 33. Djakarta (Indonesia) 1951.

E 4.2

# La Campagne Océanographique Française du "Calypso"

Par

CLAUDE FRANCIS-BOEUF

Station Océanographique de La Rochelle

Le Capitaine de corvette Jacques-Yves COUSTEAU (1) détaché de la Marine nationale va entreprendre, dans les prochains mois, une campagne océanographique autour du monde à bord du "Calypso" qui devrait durer 3 ans.

Le "Calypso" est un ex-dragueur de mines YMS de la marine américaine (U.S. Navy); sa longueur est donc de 42 mètres, son déplacement de 350 T. et il est doté de deux moteurs Diesel G.H. de 500 cv. ce qui lui permet une vitesse de croisière de 12 noeuds.

Le "Calypso" a subi de nombreuses transformations, dans ses superstructures et dans ses aménagements afin d'en faire un navire océanographique et plus spécialement un navire de recherches sous-marines. Signalons rapidement le compas gyroscopique, le pilote automatique, l'enregistreur de Cap Brown, les sondeurs à ultrasons à grande puissance, les compresseurs, un atelier mécanique, trois laboratoires dont un climatisé, une fausse étrave tubulaire permettant la prise automatique et continue de photographies sous-marines, un grande nombre de scaphandres autonomes (*a qua-long*), un scaphandre rigide pouvant descendre jusqu'à 250 mètres, des cameras et appareils photographiques susceptibles d'être immergés jusqu'aux plus grandes profondeurs océaniques.

Une première croisière d'essai doit être effectuée en mer Méditerranée et en mer Rouge. Ce n'est qu'après ce rodage que le

1) Ct. Jacques-Yves COUSTEAU: "Campagnes océanographiques françaises" 1, quai Branly, Paris (VII).

"CALYPSO" — 17. mai 1951.

Commandant J. Y. COUSTEAU compte entreprendre la campagne autour du monde, suivant un itinéraire ainsi précisement fixé: Antibes (France) — Madèire—Bermudes—Norfolk— (pour embarquer du matériel spécial) — le tour de l'Amérique du Sud (avec mission spéciale C. FRANCIS BOEUF pour l'étude de l'estuaire de l'Amazone) — Terre de feu — Terre de Graham — Pacifique Sud — Nouvelle Zélande — Australie — Indochine — Inde — Tour de l'Afrique — Méditerranée —.

Le Commandant J. Y. COUSTEAU a ainsi fixé provisoirement le programme des recherches qui seront poursuivies par les océanographes embarqués à bord du "Calypso":

PHYSIQE DE L'EAU DE MER —

*Propriétés optiques:*

a) mesures de pénétration de la lumière, suivant la verticale (3 longueurs d'onde de base).
b) mesure du coefficient d'extinction (mesure horizontale) différentes profondeurs.

c) photographie des particules en suspension et notamment des *bulles d'air.*

d) mesure photographique de la teneur en suspensions (particules organominérales et éléments planctoniques).

*Température et Salinité:*

a) mesure continue en surface (apl. JACOBSEN),

b) en profondeur, jusqu'á 1.000 mètres, dans la zone de remontées des eaux froides.

*Bathythermographie:* (en particulier, essais de sondes bathythermographiques perdues, avec enregistrement graphique, à bord, de signaux sonores).

*Etude de la couche diffusante profonde* au moyen de prélèvements d'eau massifs jusqu'à 300 mètres de profondeur, par pompe spéciale.

*Physico-Chimie de l'eau de mer* (dans les seules zones présentant un intérêt particulier, notamment en fonction de la nature des fonds et de la densité biologique).

## TOPOGRAPHIE SOUS-MARINE

*Sondages continus* par sondeurs US spéciaux à grande puissance. Essai d'un dispositif nouveau permettant de concentrer l'émission dans un angle réduit, ce qui doit augmenter la portée de l'appareil et la précision des graphiques. Cartographie et étude spéciale des canyons des grandes profondeurs.

*Photographies sous-marines à très grande profondeur* (jusqu'à 10.000 mètres théoriquement) au moyen d'un appareil automatique sans câble.

## GEOLOGIE SOUS-MARINE —

*Prélèvements d'échantillons* du fond par carouiers, ramasseurs, dragues et suceuses.

Evaluation de la *Sédimentation* au moyen d'explosions.

Etude spéciale de la *Sédimentation fluvio-marine* dans les zones tropicales.

BIOLOGIE —

Coupes biologiques de la faune fixée en un certain nombre de stations, de la surface à 200 mètres de fond, et notamment le long du continent antarctique.

Plankton quantitatif à différentes profondeurs, par filtrage d'eau pompée (pompe Mammouth).

Coupes biologiques de la faune pélagique de surface pendant les traversées (appareil photographique sous l'étrave.)

Remarque: Un certain nombre de ces techniques seront facilitées par la mise en oeuvre de scaphandres autonomes de la surface à 70 mètres de fond, puis d'un scaphandre rigide jusqu'à 250 mètres de fond.

Le programme a été établi, dans ses grandes lignes, à la suite des contacts qui ont été pris par le Ct. COUSTEAU avec les océanographes et les organismes français et étrangers et plus spécialement avec l'Institut océanographique, le Centre de recherches et d'études océanographiques, le Museum national d'Histoire naturelle, la Scripps Institution of Oceanography, l'U.S. Navy electronics laboratory, l'Hydrographic office, la Columbia university.

La présente communication n'a pour but que de solliciter de la part des océanographes réunis à Bruxelles par l'Association internationale d'océanographie physique, toutes suggestions, tous conseils justifiés par leur exceptionelle expérience. Le Ct. COSTEAU espère aussi que les océanographes qui seraient intéressés par les grandes lignes de son programme et l'itinéraire de la croisière, voudront bien collaborer effectivement avec lui en embarquant au bord du Calypso pour la réalisation d'un programme qui ne peut s'exécuter que dans l'esprit d'une coopération internationale.

E 4.3

# Oceanography in Finland

By

RISTO JURVA

Institute of Marine Research, Helsinki

The Institute of Marine Research (Merentutkimuslaitos/Havforskningsinstitutet) has continued the regular observations on ice, temperature, salinity and other chemical properties, currents and water level in the coastal region of Finland, but no regular expeditions have been made.

Among the investigations the following may be mentioned:

Professor Dr. KURT BUCH has accomplished a critical examination on the carbonic-acid equilibrium in sea water and published some papers about the increase of carbonic acid in the atmosphere and its influence upon climate.

Professor Dr. E. PALMÉN has in collaboration with Dr. WALTER MUNK from Scripps Institute of Oceanography, La Jolla, published a brief paper concerning the budget of angular momentum in the Antarctic Current.

Professor Dr. RISTO JURVA has continued his extended scientific studies on the ice conditions in the seas off Finland and published a summary about the hydrological conditions in the Baltic and a paper on the cartographical method for studies of ice.

Dr. GUNNAR GRANQVIST has finished large harmonic analyses of temperature and salinity variations of Baltic water and investigated the actual increase of salinity in the sea off Finland. Moreover the regular observations on temperature and salinity in the years 1940—46 have been published by him.

Dr. ILMO HELA has accomplished investigations on the stress of the wind on the sea surface, on the periodicity of the recent changes in the climate, on the energy exchange between sea and atmosphere

and on the wind currents in the Gulf of Finland. He has moreover published water level records for the years 1941—46.

Dr. Heikki Simojoki has published investigations on the precipitation in the Baltic sea area and on the relationship between the heat supply in the water and the freezing. He has also accomplished surveys on ice conditions in the winters 1945/46 — 1949/50 in the seas off Finland.

Dr. Eugenie Lisitzin has published the results of her investigations concerning the salinity and the current velocity in the northern part of the Baltic as well as on the hydrological conditions in the Archipelago and Åland Sea. Finally, she has published wind and current observations in the years 1943—49.

Dr. Folke Koroleff has investigated different methods for determination of traces of heavy metals in sea water and published the results of his researches concerning the dithizone method.

Magister Erkki Palosuo has been engaged with the investigation of ice conditions in the Baltic sea area and published a study on marine-biological questions.

E 4.4

# Resultats de la Mission d'Etude du Port de Safi

Par

JEAN LAURENT

Docteur Es-Sciences

Directeur Général du Laboratoire Central d'Hydraulique de France

Pour effectuer les observations et mesures concernant les phénomènes naturels à reproduire sur les maquettes, nous avons été amenés à créer, en annexe au LABORATOIRE CENTRAL D'HYDRAULIQUE de FRANCE, une Section spécialisée: la Société d'ETUDES HYDROGRAPHIQUES ET OCEANOGRAPHIQUES DU MAROC (S.E.H.O.M.).

Nous avons réalisé une liaison très étroite entre les observations en nature et les essais en Laboratoire, liaison qui constitue la base d'une nouvelle technique d'études des installations littorales.

Les Missions d'observation ont été organisées de telle sorte que soient coordonnées de façon rationnelle et scientifique les recherches poursuivies dans les différentes branches intéressées, telles que : Hydrographie, Océanographie, Géologie, Sédimentologie.

Les premières applications importantes de nos nouvelles méthodes furent faites au MAROC, et, en particulier, à SAFI. La Direction des TRAVAUX PUBLICS avait en effet élaboré un plan d'extension de ce port qu'elle désirait soumettre au contrôle du modèle réduit.

La Mission d'Etudes qui nous a été confiée avait pour objet de fournir les renseignements nécessaires à l'exécution des essais qui devaient résoudre à la fois les problèmes concernant l'agitation, et ceux concernant l'ensablement du Port.

Il y avait donc lieu d'une part, d'observer et de mesurer les caractéristiques des houles, courants, marées, etc. régnant dans

la région de SAFI et, d'autre part, de définir le mécanisme de l'ensablement.

Il est à noter que les mesures effectuées sur le modèle ont fait ressortir l'existence d'un courant débordant la grande jetée, courant qui, ne se produisant que par gros temps, n'avait pu être observé par les pratiques locales.

En ce qui concerne le mécanisme de l'ensablement, il a été mis en évidence de la façon suivante:

Les Mesures Océanographiques on montré que les actions de transfert étaient dues presque exclusivement à la houle;

Les Mesures Hydrographiques ont permis de reconnaître l'évolution des plages situées au Nord du Port dans différentes circonstances et d'évaluer le volume annual des transits : 150 000 mètres cubes.

Il existe de SAFI au Cap CANTIN, une falaise jurassicocrétacée, encadrée au Sud et au Nord par des formations quaternaires qui donnent naissance à des sables de composition identique à ceux qui envahissent l'Avant-Port.

Cependant, l'hypothèse d'une alimentation à partir du Sud a dû être éliminée catégoriquement lorsque nous avons constaté que les depôts de dragages effectués par fonds de — 13 mètres, au large de la Grande Jetée, n'évoluaient pratiquement pas. Cette Grande Jetée gagne en effet des fonds de même profondeur, ce qui exclut qu'elle puisse être contournée par une masse importante de sédiments.

L'alimentation à partir de la région située au nord du Cap CANTIN était donc la seule possible. Elle s'est trouvée confirmée par le fait que tout le long de la falaise jurassico-crétacée, qui avance les formations quaternaires, nous avons constaté la présence d'un cordon littoral sous-marin formé des sédiments qui envahissent l'Avant-Port.

Les mesures et observations ont permis de définir une "isobathe critique", pratiquement située à la limite de la zone de déferlement et au-delà de laquelle les transferts sont pratiquement nuls.

Enfin les résultats fournis par la Mission d'Etudes ont permis de suggérer la construction d'un épi destiné à arrêter les sables au nord du port.

E 4.5

# Oceanographie Physique en Espagne 1948—1951

Par

N. MENENDEZ

Instituto Español de Oceanografia

L'Institut Espagnol d'Océanographie continue l'étude des courants dans la mer d'Alboran, située au Sud de l'Espagne et entre 2° et 5° W. Après une interruption de presque deux années, imposée par les insuffisances de matériel d'observation, on fait trois campagnes océanographiques dans la mer d'Alboran. Dans ces campagnes on a déterminé, par les méthodes connues, la structure thermohaline et, éventuellement, l'oxygène contenu.

Dans la communication présentée à l'Assemblée Générale à Oslo, nous avons signalé que l'eau superficielle comprise entre le détroit de Gibraltar et le méridien 3° W, avait partout les caractéristiques des eaux d'origine atlantique. A cause de cela nous avons prolongé la limite de la région de la mer d'Alboran jusqu'à 2° W, où, au Nord, nous trouvons de l'eau superficielle méditerranéenne pure, au spécifiant la limite de la convergence des deux courants, méditerranéen et atlantique. La détermination de cette zone de convergence semblerait être d'une grande utilitée pour continuer l'étude de la contribution de l'eau atlantique à travers le Détroit, suivant les conditions climatologiques diverses de la région hydrologique méditerranéenne.

De cette façon nous avons obtenu des données pour l'hiver et pour l'été le long des méridiens 2° — 2° 30' — 3° — 3° 30' — 4° — 4° 30' et 5° W. Les prises d'eau les plus profondes ont été faites à 900 m et la distance entre les stations d'un même profil étaient d'environ 10 milles. Leurs positions ont été choisies en accord avec la topographie du fond.

Malgré l'intérêt qu'elle présenterait nous n'avons pas pu réa-

liser la même étude pendant le printemps et l'automne à cause des difficultés économiques.

Pour le calcul des courants nous avons adopté comme couche de référence, la couche de salinité 38 $^{0}/_{00}$, qu'est la partie inférieure de la zone de transition entre l'eau superficielle et l'eau du fond. De cette façon, les résultats sont plus en accord avec la direction des courants indiquée par la salinité, que si l'on avait choisi comme référence la couche la plus profonde observée. L'on trouve des difficultés à cause des oscillations de la couche de référence et des variations de la structure thermo-haline dues aux marées internes. Ces perturbations sont plus évidentes dans les profiles voisins du coté oriental du Détroit.

Pour les corriger et réduire, à chaque station, la structure thermo-haline trouvée à la structure normale, nous avions prévu une étude des ondes de la marée interne d'après les traveaux de Fjeldstad et en utilisant des observations de trois stations ancrées faites sur le parallèle 36° N et les méridiens de trois profils différemment éloignes du coté oriental du détroit. N'ayant pu mettre au point le dispositif d'ancrage convenable pour les profondeurs existant dans cette region, légèrement superieures à 1100 m, nous avions prévu de maintenir le bateau sur une surface d'environ 8 milles carrés et d'envoyer des séries de bouteilles à renversement, aussi souvent que possible, pendant 36 heures. Ceci a été réalisé seulement pendant 14 heures à une seule station fixe et en faisant des prises toutes les heures, et à quatre profondeurs aux environs de celle de la couche de salinité 38 $^{0}/_{00}$.

Les données de toutes ces campagnes ont été rassemblées et pour la plupart traitées; notre désir est d'essayer de nouveau l'étude de stations ancrées nécessaires, de façon à obtenir les corrections indispensables et les appliquer à l'obtention de résultats qui seront alors publiés et envoyés aux membres de cette association.

# Symposium: Exploring the Ocean Floor.

F 1

## Stratigraphy and Chronology of Ocean Sediment

By

H. PETTERSSON

Oceanographical Institute, Gothenburg

Studies of the sediment in long cores raised during the Swedish Deep-Sea Expedition have given new aspects on the stratigraphy and the chronology of the ocean bottom. The analysis of the microfossils contained *viz.* foraminifera, radiolarians, diatoms etc. give indications of climatic variations, of variations in the sedimentation process and also allow of correlating the strata in different cores over great distances, sometimes even back into the Tertiary Age. Of the means available for studying the chronology of the ocean sediments and their varying rate of sedimentation, foraminifera analysis, radium measurements and, in some regions, the presence of volcanic ash layers, appear most promising. Stratified sediments, which are specially prevalent near the counterequatorial Current, afford means of studying the oceanic circulation of the past.

The results already gained underline the importance of international cooperation on a large scale in future studies of the ocean floor and of its sediments.

F 2

# Chemical, Mineral and Physical Changes in Deepsea Cores

By

JOHN D. H. WISEMAN

British Museum (Natural History), London, S. W. 7

Through the kindness of Prof. HANS PETTERSSON, the British Museum of Natural History has been fortunate in obtaining a long globigerina ooze core nearly 14½ m in length, collected by the KULLENBERG Piston Core Sampler, from a depth of 4350 m in the Equatorial Atlantic Ocean (1° 10' N. 19° 50' W). The core is essentially composed of planktonic foraminifera, together with a clay component. Bottom living organisms (benthonic foraminifera holothurians etc.) as well as diatoms and radiolaria are poorly represented. Ash and sand bands and extraneous terigeneous material are absent. Normal silicate minerals are very rare. The core was apparently undisturbed during the process of coring, and there is little evidence of disturbance by bottom living organisms. The sedimentation during the period represented by the core was apparently continuous and undisturbed, and there is no evidence of deposition by density currents and mud flows. The core is, therefore, admirable for detailed investigations.

The work done on this core has been chemical, mineralogical, physical and biological. It is considered most desirable to combine as many methods of investigation as possible if the difficulties of interpretation are to be overcome. The chemical work (all determinations in duplicate), as well as the biological have been undertaken on half a cm thick slices of the core taken every 5 cm. The chemical investigations so far undertaken on 290 samples have been (a) loss of water at 106° C after the sample had been brought

into equilibrium in an atmosphere of constant humidity (b) $CO_2$ and (c) Cl. New methods have been developed. The reproducibility of the methods is shown by the fact that in 100 samples done in duplicate, fifty did not differ more than 0.03 % for $CO_2$. In the case of Cl, fifty of them differed by less than 0.004 %. A plot of the chemical variations was shown on a 4 m graph. The variations are clearly not haphazard, for any major change is gradual and normally takes place over a core length from 20—40 cms. There is a clear reciprocal relation between the $CO_2$ and the loss of water at 106° C, the $CO_2$ curve oscillates with a certain degree of regularity about a general average.

As the content of benthonic foraminifera is small and remains constant, changes in the $CO_2$ content can be interpreted as a reflection of the changing productivity of the Planktonic foraminifera provided that: (a) the rate of sedimentation of the non-calcareous components has remained constant with time and (b) that there has been no solution of the calcareous tests. As the curve showing the loss of water at 106° C is proportional to the amount of clay present, a decrease of the $CO_2$ content cannot be explained through the incoming of non-hydrous components for if this were the case, there would be no reason for a reciprocal relation between the $CO_2$ and water curves. This, however, does not prove that a decrease of $CO_2$ is not related to an increased rate of sedimentation of the clay component, or to a solution of the calcareous tests. Whilst it is impossible at this stage of the investigations to rule out this possibility, there are, nevertheless, indications that the fundamental changes of $CO_2$ are not related to changes in the rate of sedimentation of the non-calcareouscomponents or to solution. For instance, the grain size on distribution of the foraminifera is coarser in those portions of the core where the $CO_2$ is high than where the $CO_2$ is low. Such a relation would not exist if a reduction of $CO_2$ was merely related to an increased rate in sedimentation of the non-calcareous components. Further there are no more obvious signs of solution where the $CO_2$ content is low than were it is high. The fact that the core was collected at a depth corresponding to the maximum $CaCO_3$ in the Atlantic is of some significance.

It is concluded, therefore, that in the case of this core, the $CO_2$ variations are a reflection of the changing productivity with time

of the planktonic foraminifera. As there is reason to believe that the minimal factor governing the productivity of planktonic foraminifera is temperature and not the availability of food supply the changing $CO_2$ content should be a reflection of the changing sea-surface temperature at the locality where the core was collected. The statistical foraminiferal investigations so far as they have gone support this conclusion; for where the $CO_2$ is high, the foraminifera are warm species and where the $CO_2$ decreases there is an incoming of more temperate forms.

From a knowledge of the distribution of $CaCO_3$, the original water content, and provided there has been no appreciable change in the rate of sedimentation of the non-calcareous component, nor solution of the carbonate tests, it should, theoretically, be possible to calculate the age of any portion of the core, if the age of one portion of the core is known. On the assumption that the maximum content in the $CO_2$ curve corresponds to the Climatic Optimum, believed to be about 3.000 B. C. provisional age calculations have been made. It is of interest to point out that according to these provisional calculations the sea-surface temperature about 10.000 B. C. was appreciably colder than it is to-day, and this is in remarkable agreement with the age of the Mankato phase of Wisconsin glaciation, which, according to $C^{14}$ measurements published this Spring, is about 9.500 B. C. From the nature of the $CO_2$ curve, it is likely that errors caused by small departures from the ideal conditions would cancel out.

A new bulk analysis of the fine fraction ($<1\mu$) of a deep-sea deposit was given. In this poorly crystalline substance, which does not correspond chemically with illite, there is one atom of K to every 0.06 atoms of Na. It is suggested that the high ore content of Na in the sea with reference to K could be maintained by a continuous abstraction of K on poorly crystalline hydrous Al, Fe silicates. The fine fraction of deep-sea deposits would, in the general case, have a composite origin for it may be (a) transported from the land by varying agencies (b) derived from existing sediments on the deep-sea floor (c) formed by submarine weathering or (d) prepotated from the sea. In special areas one of these factors may predominate.

F 3

# Foraminifera and Paleoceanography

By

FRED. B. PHLEGER

Marine Foraminifera Laboratory, and Scripps Institution of Oceanography, La Jolla, California, U.S.A.

Foraminifera are both benthonic and planktonic in habitat and have a variety of adjustments to the marine environment. When they die or reproduce their tests become a part of the sediment and can thus be used to decipher a sequence of marine environments from deep-sea cores.

Knowledge of the ecology of Foraminifera is very incomplete. The principal important results are as follows: 1) Depth biofacies of the benthonic assemblages are established in parts of the northwest Atlantic and northeast Pacific. 2) The brackish water and nearshore marine assemblage of benthonic types is generally defined. 3) There is some information on the geographic distribution of planktonic types; this is based, almost exclusively, on their distribution in bottom sediments, which is not a completely reliable method. There is little information on the causes for Foraminifera distributions. The method of collection and of analysis is of primary importance in studying distributions of planktonic and benthonic forms.

The principal results obtained by application of ecologic information to paleoceanography are as follows:

1) The displacement of marine sediments down-slope over large horizontal and vertical distances has been proved by benthonic Foraminifera displaced out of their normal depth ranges. This mechanism for deep-sea sedimentation has far-reaching implications, and occurs in all oceans.

2) Recent changes in the relative level of the sea have been

demonstrated by the sequence of benthonic Foraminifera in short cores in the southwest Gulf of Maine and the northwest Gulf of Mexico.

3) Changes in "water climate" are based on the vertical distribution of planktonic Foraminifera in long submarine cores. These are correlated with Pleistocene climatic changes by inference; correlation in the strict geologic sense is not possible since there are no fossils and the faunas cannot be matched between regions. The presumed "glacial" faunal sequences are reported as widespread in Atlantic areas, and also present in the Mediterranean and Arabian seas.

Fossil assemblages recently discovered in a few long cores from the southern North Atlantic may indicate a regular transition from the modern assemblage to a Miocene one. The probable Miocene fossils are planktonic types and occur 8 to 10 meters beneath the surface of the sediment. Most Atlantic deep-sea cores do not contain fossil assemblages and may represent relatively rapid deposition.

Solution of the calcium carbonate of Foraminifera tests in deep-sea deposits occurs but is not consistent.There is an apparent correlation with depth in cores, but this is not consistent. Much solution may be post-depositional. It is possible that calcium-carbonate solution may have important paleoceanographic implications.

F 4

# Seismic Investigations in Great Ocean Depths

By

MAURICE EWING

Department of Geology, Columbia University, New York

Since 1935 our group has been investigating the continental shelf by seismic refraction methods, and now has good information on the depth of basement rocks from Cape Hatteras to Halifax.

Until recently there were only very rough estimates of the total thickness of sediments on the ocean floor and it was uncertain whether or not the crustal rocks under the ocean basins were fundamentally different from those under the continents. The seismic refraction method, whose adaptation for oceanic investigations for the technique of the petroleum geophysicists has been our major concern since 1935, has given clear answers to both of these questions.

During the summer of 1950 our work showed that within a circular area centered approximately on Bermuda and having a diameter of about 1500 miles, the deep sea sedimentary layer was mostly unconsolidated and somewhat less than a kilometer thick. It was underlain by a layer of ultrabasic rock with sound velocity 6.9 km/sec, approximately 5 kilometers thick. Immediately beneath this layer is matter in which the sound velocity is somewhat greater than 8 km/sec, believed to be identical with that found beneath the continents at 30 or 40 kilometers.

Thus the seismological results reinforce those from investigations of isostatic equilibrium revealing the continents as blocks of sialic rock floating in a simatic substratum, and the completeness of the segregation of the sialic rocks into continents is underscored as one of the major problems of geology.

A new investigation of the surface waves from earthquakes

in which the effect of the ocean's water was properly reckoned for the first time, has furnished additional evidence for the contrast between continental and oceanic crust and has proved that the Bermuda area, whose detailed investigation by the seismic refraction method was mentioned above, is typical of the oceans of the world.

A third seismic method — an adaptation of the seismic reflection method of the petroleum geophysicists — was used extensively from 1946 to 1948. It was easy to apply, as the measurements could be made without stopping the ship. But it gave little information: exceedingly complicated reflections in the flat bottoms of the great basins, and exceedingly simple reflections in the gentle slopes which rise from the ocean floor. We know that we were mapping stratifications within the sediment, never basement rocks, and that the complexity in the basin floors arose from the stratification of "transported" sediments, the simplicity in the higher parts from the very homogeneous column of "proper" deep sea sediments.

Preliminary results from recent seismic refraction work show true ocean crust within the Caribbean and a thickness of unconsolidated sediments in the Puerto Rico Trough so great that we could not penetrate it with the explosives available to us.

The relation of these results to ocean basin sedimentation, to the results of gravity surveys, and to the origin of continents is discussed.

F 5

# Recherches sur les Gorges Sous-Marines (Submarine Canyons) du Golfe du Lion

Par

J. BOURCART

Professeur à la Sorbonne

Il semble que ce soit MARION qui, en 1885, ait le premier découvert une incisure dans le Rebord Continental figuré souvent encore aujourd'hui comme la corde de l'arc, tendu entre le Cap Creus et Sicié. En effet dans un mémoire célèbre de la Société de Biogéographie de Marseille, il décrit la profonde vallée de Cassis.

De 1894 à 1895, Georges PRUVÔT, Sous-Directeur du Laboratoire de Banyuls-Sur-Mer (Université de Paris) levait en détail deux vallées qu'il baptisait »Rech« (c'est à dire Ruisseau en Catalan), au large du Cap Creus et de Port-Vendres.

De 1934 à 1937, l'Ingénieur Hydrographe MARTI, inventeur du sondage au son, et ses collaborateurs, lèvent les zones profondes du Plateau Continental du Golfe, de la frontière Espagnole à Cannes. Mais ce levé ne fut publié qu'en 1947.

Ce Plateau est entaillé d'au moins 12 gorges profondes à peu près perpendiculaires aux courbes de niveau, présentant parfois des affluents. Deux autres, la Rivière du Lavandou et celle de St. Tropez sont en revanche, parallèles au rivage.

A partir de 1946, j'ai pu, avec mes collaborateurs, sur divers bâtiments de la Marine Nationale, entreprendre le levé de détail et des dragages longitudinaux et transversaux de plusieurs de ces gorges.

Les principaux résultats sont les suivants:

— la pente des vallées augmente progressivement de la région de Sète à Toulon et de Toulon à Nice alors que le Plateau Con-

tinental défini bathymétriquement se réduit à peu près à zéro, la pente étant d'autre part minima pour les vallées parallèles au rivage.

— si l'on définit le plateau continental par le lieu même de ces gorges, il vaut mieux dire que sa déformation croît régulièrement de Toulon à Nice.

Les dragages transversaux ont montré que dans les Pyrénées Orientales au droit d'une montagne cambrienne, le plateau est formé d'une épaisse série Miocène, reposant probablement sur du Nummulitique. Au contraire de Cassis et de St. Tropez, c'est un massif des Maures élargi (Schistes métamorphiques, gneiss, granites), dans lequel est entaillée la gorge.

Un quaternaire littoral uniforme pour tout le golfe, forme la dalle supérieure de ce Plateau.

Le remplissage des vallées, par contre, est fait de cailloutis fluviaux, recouverts de sables vaseux à faunes boréales (dernière fusion glaciaire), puis en général de 2 m de vase à microfaune actuelle.

Le creusement de ces gorges, commencé très probablement au Villafranchien, n'a pu reprendre que pendant le très court intervalle entre le Quaternaire ancien (Tyrrhénien ?) et la transgression flandrienne. Certainement fluvial, il supposerait une régression eustatique d'au moins 2000 m, profondeur du delta terminal de la gorge de Toulon. Celle-ci étant impossible en Méditerranée, il est nécessaire d'imaginer des déformations récentes de l'écorce. L'étude de l'exagération de la pente initiale des gorges et celle des calcaires littoraux quaternaires, recouvrant le plateau, pourra permettre de la chiffrer.

F 6

# On the Origin and Environment of Marine Sapropelium

By

MARGARETHA BRONGESRMA-SANDERS

Leiden University, Netherlands

Well preserved fossil vertebrates often occur in highly bituminous shales; sometimes even soft animal tissue has been preserved. What was the miracle inhibiting bacterial action and decay? To find the solution of this problem we have to search for causes why the animals very shortly after death have been cut off from oxygen bearing water.

Highly bituminous sediments as the permian Kupferschiefer, the oligocene menelite shales of the Carpathians, etc., are sapropelites. To understand the conditions under which the fossils were embedded, the origin and environment of recent sapropelium has to be studied. In fresh water the chief causes leading to the formation of sapropelium are persistent stagnation of the lower water layers, and hypertrophy. Instances of such fresh waters are given. Persistent stagnation was supposed to be the only possible cause for the formation of marine sapropelium (instances: the deep water sediment of the Black Sea, the sediment of some Norwegian threshold fjords). Sp. emphasizes that in sea hypertrophy may also lead to sapropelium. Hypertrophic conditions in the first place occur in regions of upwelling (instances: Walvis Bay and open sea outside it (S. Africa), open sea near Cape El Hadd (Arabia), Bay of Talcahuano (Chile)); the nutrients required for the extensive production of plankton here are supplied by the deeper layers of the oceans. This manner of occurrence of hypertrophic conditions has been discussed by the sp. already in a paper of 1948. There

are, however, other conditions leading to hypertrophy, which in all probability even occur more frequently. These conditions prevail in some seniseparated parts of the sea, where nutrients accumulate that derive from the surrounding land. The fertility of the hinterland, the supply with river water, the shallowness of the sea, and other factors are decisive whether or not the situation becomes hypertrophic (instances: S. Russian limans; the Sea of Azov (S. Russia) is nearly hypertrophic).

Sp. remarks that in most marine sediments vertebrate remains are strikingly scarce; in hypertrophic regions, however, such remains locally may be abundant. Sinking down after death into the pappy mass of sapropelium, in which anaerobic conditions prevail, the remains very soon become cut off from oxygen which results into favourable conditions for fossilisation. Hence in hypertrophic regions there are, in statu nascendi, fossil deposits rich in vertebrate remains. Sp. presumes that several bituminous shales also originated under hypertrophic conditions. A striking peculiarity of some of these shales is the local abundance of vertebrates and of other animals. This reminds of the abundance of animals in regions of upwelling and in other highly productive areas. The cause of death of the fossils, and other problems concerning such shales are discussed.

F 6.1

# Le Plateau et le Talus Continental de la Cote Africaine de l'Atlantique Sud

Par

Monsieur ANDRE CAPART

Conservateur-Adjoint à l'Institut Royal des Sciences Naturelles de Belgique

Chef de l'Expédition océanographique Belge dans l' Atlantique Sud 1948—1949

(Résumé de la Conférence du Comité National Belge de Géodésie et de Géophysique. Séance du Jeudi 19. avril 1951.)

Délimitation de la zone étudiée au cours de l'Expédition océanographique Belge „MBIZI" dans l'Atlantique Sud 1948—1949; au cours de laquelle cette étude a pu être réalisée (de l'équateur au tropique du Capricorne).

Quelques précisions sur la méthode de sondage, profils effectués, routes suivies, etc....., (démonstration d'une coupe montrant les différents aspects des échos enregistrés suivant la nature des fonds sondés).

Description de l'allure générale du plateau continental, son relief et la nature des fonds dans différentes zones. Essai d'explication de l'origine des bancs de sable ou de vase; principalement dans le cas de la région située au large de l'estuaire du Fleuve Congo.

Caractéristiques du banc de vase du Congo, mesure de son épaisseur, structure relevée par l'écho-sondage.

Quelques remarques comparatives sur les bancs vaseux situés au large des autres grands fleuves africains.

Caractéristiques du plateau continental au Sud du 16° Lat. Sud et l'influence du courant du Benguela.

Aspect général du talus continental dans la zone étudiée, sa pente, son relief, la nature des sédiments, etc...

Quelques remarques sur les Vallées sous-marines sud-africaines étudiées et les déplacements récents des embouchures de plusieurs fleuves.

Les pointes de sable de la côte, description rapide de quelques exemples curieux, dont la Pointe de Banana; causes possibles de sa formation et de ses variations.

F 6.2

# Sea Floor Results: Scripps-Navy Mid-Pacific Expedition, 1950

By

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As a part of a general oceanographic research program, the abyssal Pacific sea floor was investigated on the Scripps-Navy Mid-Pacific Expedition by means of continuous echo sounding, coring, dredging, bottom photography, seismic refraction, and a bottom temperature probe.

Two major geographic discoveries were (1) a large and deep submerged mountain range lying between the Hawaiian Is. and Wake I. and (2) a 1 000-mile-long and one-half-mile-high south-facing escarpment extending westward from Cape Mendocino, California. Also, the soundings revealed significant geomorphic data on the Hawaiian structure.

E. L. Hamilton has identified fossiles dredged from the 1 000-fathom tops of guyots of the Mid-Pacific Mountains as a Mid-Cretaceous shallow water reef coral-stromataporoid-rudistid fauna. It appears that the mountain range was formed in the Cretaceous and that scattered volcanic islands of olivene basalt were present. These were truncated by wave action and coral reefs grew. The reefs were subsequently deeply drowned probably largely because the mass of the volcanos exceeded the long-term strength of the crust. The guyots presently rise two miles above the abyssal floor; therefore, regardless of the cause of drowning, the Pacific appears to have been a deep basin at least since the mid-Cretaceous.

The Mendocino Escarpment is considered by H. W. Menard and the speaker to mark an abrupt lithologic boundary in the

crust because there is a regional shoaling of the sea floor to the north. Thus, the scarp may be structurally analogous to a continental slope. Faulting appears to have taken place along the scarp but the nature of the movement is problematical.

The Hawaiian Islands are superposed on a 600-mile-wide swell. A moat-like deep is present at the base of many of the islands. Outside of the deep there is an arch. It is postulated that the swell is due to a bulging of the crust above the divergence between two thermal connection cells. The islands are volcanos formed above fissures in the center of this bulge. The moat-like deeps and the arch are considered to be related to isostatic subsidence of the islands. Deep terraces with a maximum depth of at least 700 fathoms around some of the islands are thought to be drowned shelves.

Bottom photographs of the 750-fathom top of Sylvania Seamount show coarse oscillation ripples in globigerina ooze. Thus, strong oscillatory currents occur in the ocean at great depths.

The possible crustal structure of the Pacific floor will be briefly discussed in the light of R. W. Raitt's seismic refraction data. Some values of the temperature gradient in the sea floor as determined by J. Snodgrass and A. Maxwell will also be presented.

F 6.3

# Seismic Refraction Shooting at a Point in the Eastern Atlantic

By

MAURICE N. HILL

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For the experiments described in this paper a new method of refraction shooting was developed. With this method hydrophones suspended at a depth of about 30 m below the surface of the sea acted as receivers while depth charges exploding at a depth of about 270 m provided the sources. The hydrophones were connected to sono-radio buoys which radio transmitted the signals to a recording system in the ship from which the charges were dropped. Four buoys were in use simultaneously distributed at differing ranges from the ship.

The experiments were carried out at three positions in an area of the Eastern Atlantic around the point 53° 50' N, 18° 40' W, where the water depth is approximately 2.400 m. The results showed the uncrystalline sedimentary layer in this area varied in thickness from 1.900 m to 3.000 m and that the velocity of compressional waves in it increased from the value of sea water, 1.5 Km/sec., at the surface with an approximately constant gradient of 2.5 /sec. to a limiting value of 2.5 Km/sec. Below the sedimentary layer there was a crystalline rock with velocity 5.0 Km/sec. and of thickness varying between 2.7 Km and 3.4 Km. The base of this layer was about 7.8 Kms below sea level. The lowest layer concerning which results were obtained gave a velocity value of 6.3 Km/sec., but was of undetermined thickness.

F 7

# On the Properties of the Water Layers close to the Ocean Floor

By
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With the intention of studying the physical and chemical processes involved in the formation and geochemistry of deep sea sediments, samples close to the ocean floor were taken by the Swedish Deep Sea Expedition. The lowest watersampler was about 3 to 5 m above the bottom and the others were 6, 12, 25, 50 and 150 m above this.

It could be shown that all elements investigated, such as silica, phosphate-phosphor, oxygen, chlorinity as well as hydrogen ion concentration and temperature vary near the ocean floor in a typical manner. From the distribution it could be concluded that the currents in the deep sea erode hills and thresholds. The eroded fine material is transported in clouds from these hills and exposed to the action of seawater. Thus the silica and phosphate is easily dissolved causing a maximum in these layers. The maximum was found in 10 to 50 m above the bottom. By mixing and diffusion a certain amount of these elements is drawn from this maximum to the upper water layers and there consumed by organisms. The usually high gradient of silica, phosphate and oxygen towards the bottom indicates that organic and probably chemical processes in and on the surface of the sediments consume these elements.

These determinations show that we have to do with an erosion by currents, solution of sediments *i.e.* weathering, organic and chemical reorganisation of certain elements followed by the concentration of the elements on certain places. This effect can become dominant for the distribution of soluble elements, when the supply from the upper layers is low or the currents are strong.

F 7.1

# Graded and non-graded Deep-sea Sands

By

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Beds grading from coarse at the bottom to fine at the top can be deposited in shallow and deep water. Sandstorms, volcanic eruptions, stormwaves, normal currents, and turbidity currents can each be responsible. An attempt has been made in cooperation with Menard of San Diego, to find distinctive characteristics for the deposits laid down by each of these agents. Experiments show that turbidity currents can sometimes also deposit beds which show hardly any grading. The deposits of submarine mudflows are never graded.

F 8

# Significance of Foraminifera as Indicators of past Climatic Changes

By

C. D. OVEY

British Museum (Natural History)

In WISEMAN and OVEY (1950, pp. 58—64) it was definitely shown that in general terms certain planktonic foraminifera could be used to reflect temperature conditions of surface waters of the ocean (op. cit., p. 60, Table II and p. 62 fig. 2) where they must have lived for at least part of their existence. In spite of the fact that the bottom samples used in this test were taken from Museum samples collected by various expeditions such as the CHALLENGER and it is not possible to know to what depth in the bottom sediment these were originally dredged, the faunal contents bear an obvious relationship to the sea-surface temperature.

The species used in the counts were those originally used by PHLEGER (1948) in his examination of a core from the Caribbean and for this reason were purposely chosen; and, through his courtesy, it has recently been possible to confirm identity of species by a comparison of specimens used by himself and F. L. PARKER with those used in the British Museum (Natural History).

The method of counting the species-content per 1.000 specimens has been found to be valid by performing two counts for each of two samples in which the percentage deviation of each was 0.9 and 0.8 respectively (OVEY, 1950, p. 212 and p. 213, fig. 1).

It is stressed that results obtained by applying this quantitative method of counting to the examination of material from deep-sea cores is in no way conclusive and the author is fully aware of the many problems concerning the little-known life history or ecolo-

gical controls of the species concerned. However the test described in WISEMAN and OVEY (1950) already mentioned is sufficient to show that *a priori* temperature control in the upper water layers dominates distribution of planktonic foraminifera.

Results have shown that, in the Swedish Deep-sea Expedition's Core 241 from the Equatorial Atlantic, temperature fluctuations can be determined by means of the quantitative analysis of the planktonic foraminiferal assemblages in each sample. Early results of this investigation have been published (OVEY, 1950, pp. 213, 214, figs. 2 and 3). Peaks of high percentages of warm water species have been found to correspond to a high percentage of $CO_2$ according to the analysis being carried out under the direction of WISEMAN, and, conversely, lower percentages of warm water species correspond to lower $CO_2$-content. Any change in water mass is bound to disturb the foraminifera-$CO_2$ relationship and for this reason it is obvious that a standard relationship cannot be established. A few samples recently sent the author by Mr. CR. ARRHENIUS for examination from the Equatatorial Eastern Pacific indicate this, for the $CO_2$ percentage in these samples is very much lower for a high warm water percentage of planktonic foraminifera than it is for the warmest sample of Core 241 in the Equatorial Atlantic. *e. g.*,

"Warmest" samples so far examined

| *Eastern Pacific* | | *Equatorial Atlantic* | |
|---|---|---|---|
| Warm Foraminifera % | $CO_2$% | Warm Foraminifera % | $CO_2$% |
| 99.2 | 36.8 | 97.1 | 40.0 |

From a cursory examination it is obvious that the lower $CO_2$% in the Eastern Pacific samples is due to the high content of Radiolarian siliceous tests and not to clay content. It therefore seems likely that the application of the Foraminifera-$CO_2$ relationship is of little value in the elucidation of past temperature changes in the surface waters of that part of the Pacific.

It is expected that, as knowledge of their distribution increases, it will be possible to divide planktonic foraminifera into finer temperature indicating groups but there are many difficulties in this

respect. The origin of water-masses, the tolerance to temperature-change limits and survival of species carried out of their normal environment are among these.

The author is particularly grateful that he has had the opportunity to discuss with Dr. FRED B. PHLEGER during this Assembly questions concerning these investigations. It has been found that the work being carried out on the two sides of the Atlantic in this sphere can on the whole be integrated. Although it is being carried out on different lines there is no need for dispondency that the investigations cannot be reconciled.

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F 9

# Discussion sur la Structure du Fond de l'Ocean Atlantique

Par

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L'auteur a proposé en 1947 une hypothèse de travail concernant la structure du fond de l'Océan Atlantique: la crête médiane (»Mid-Ridge«) partagerait l'Océan en deux domaines: l'un à l'Est à caractère *continental* constituerait la marge du bloc eurafricain, l'autre à l'ouest serait à caractère *simatique*.

L'existence d'une zone séismique continue qui prolonge vers l'Ouest la zone séismique alpine mésogéenne (Alpes occidentales, Apennins, Atlas) et qui rejoint, *sans la traverser*, la zone séismique qui jalonne la crête médiane de l'Atlantique est certainement l'un des arguments les plus importants en faveur de l'hypothèse.

La valeur très élevée de la vitesse des ondes séismiques superficielles propagées sous la partie occidentale de l'Atlantique, déjà signalée par Lynch, a été confirmée par les recherches de P. Caloi et de ses collaborateurs (4,3 à 4,4 Km/sec. pour des ondes de 24 sec. de période). La vitesse moyenne des ondes de Love pour le séisme étudié par P. Caloi est plus forte de 0,4 Km/sec. lorsqu'on la mesure à Ottawa au lieu de la mesurer dans les trois stations européennes de Tortosa, Jersey et Barcelone bien que les trajets continentaux et océaniques suivis par les ondes pour atteindre ces 4 stations soient du mème ordre de grandeur. Il paraît donc aujourd'hui très probable que le substratum de la partie Ouest de l'Atlantique est analogue au fond simatique du Pacifique. L'interprétation séismique est moins nette en ce qui concerne la partie orientale et demande de nouvelles vérifications.

De nombreux autres arguments sont passés en revue: forme différente des côtes sur les deux rivages de l'Atlantique; prolongation en mer des unités morphologiques africaines; existence d'anomalies négatives de gravité le long de la »boucle« des Antilles; draguages de tachylyte (Termier), de Trilobites (Furon), de calcaires d'âge tertiaire (Ewing et Tolstoy) dans la partie orientale de l'Atlantique; théorie des chaînes liminaires (Glangeaud); résultats *en apparence* contradictoires des prospections séismiques par réfraction obtenues dans l'Atlantique à l'Ouest de l'Ecosse (Hill) et au voisinage des Bermudes (Ewing).

Les récents travaux du Père Poisson à Tananarive indiquent un retard dans la durée de trajet des ondes séismiques longitudinales qui se propagent vers l'Ouest à partir de la dorsale de l'Océan Indien; par ailleurs plusieurs géologues considèrent que l'existence d'un continent de Gondwana est une notion périmée.

L'auteur est amené à penser que le véritable bloc continental africain est en réalité limité par la crête médiane de l'Atlantique et par la dorsale de l'Océan Indien.

# Papers on Currents

G 1

## Some New Work on Currents-Observing in the Seas around Britain

By

J. N. CARRUTHERS

Hydrographic Department, British Admiralty

World War II caused the cessation of a programme of continuous observations on the water movements past various British and other lightships, which had, as its main object, the procurement of a synoptic picture. As many as ten positions were involved. Accrued data amounting to some 8.000 days of continous observing have been very fruitfully applied in marine biological connections. This last year has seen the resuscitation of the programme, and the work is already in train again from about nine lightvessels. This last June will have seen the application of important new effort thanks to German co-operation. Ten Schaufelrad current-meters will have been operated along chosen lines in the southern part of the North Sea, contemporaneously with the working of the Vertical Logs from the lightvessels. The large self-moored and unattended version of the Vertical Log has been employed at one position in the English Channel, and the self-anchoring, self-signalling, and self-timing deep-riding float formerly known as the Lowestoft Crossbow Float, has been adequately developed and used in preliminary experiments. It is confidently expected that the continuous observing from lightships will be extended as means become available. Meantime a spoken account is given

to convey something of what has so far resulted from the work recently re-started, of the applications envisaged, and of the extensions intended and hoped for. A plea is made for as much international co-operation as possible.

## Supplement

By

G. BÖHNECKE

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Of the ten paddle wheel (Schaufelrad) current meters laid out in the Hoofden area, one was lost. Two of them fouled fishing nets, and were recovered with the kind assistance of Belgian and Dutch authorities. In view of the short time available, only one station has so far been evaluated, *viz.* No. 14 at the south west corner of the area (*vide* paper of Dr. CARRUTHERS).

It was evident that residual current at this station, during the period of observation concerned, oscillated between south and south-east, and was closely related to the direction of the wind. The evaluation of the other stations will be continued. It is hoped that the results can be submitted soon.

G 1.1

# A Survey of the Benguela Current

By

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British National Institute of Oceanography

On two occasions, in March and September, 1950, observations were made across the continental shelf off the coast of south-west Africa between 19° and 29° S. During the first survey the winds were mainly north or calm and there was little evidence of active upwelling; during the second period the winds were mainly south-east and upwelling was a marked feature. The temperature and salinity data show that the surface water near the coast on 29° S has the same temperature salinity relationship as the bottom water near the outer edge of the shelf in 19° S, and indicate that there is a gradual descent of water from south to north. The evidence of such a movement helps to explain the decrease in oxygen content of the water, and the widening of the area marked by the low oxygen content, towards the north.

G 2

# Preliminary Notes on the Countercurrent of the Indian Ocean

By

N. G. JERLOV

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During the first half of March 1948 the Swedish *Albatross*, on a northerly route near 88° E, crossed the system of equatorial currents in the Indian Ocean. Seven hydrographical stations were occupied in this section from 11° S to 2° N. The prevailing winds were slight.

Vertical sections of temperature, oxygen, and phosphate distribution between the surface and 300 m bring out fairly small variations, but indicate the presence of a Countercurrent. On the other hand, the salinity distribution clearly shows the structure of the water masses. A low salinity is found between 9° and 6° S, whereas to the north of 5° S the water is characterized by a high salinity. Thus, water of 35 $^{0}/_{00}$ salinity is present in the surface between 4° and 2° S.

An especially interesting feature is the distribution of particles studied by means of a Tyndall-meter. In the upper strata the amount of phytoplankton, which constitutes a considerable part of the total particle content, will respond very sensitively to the richness of nutrients. Consequently, the presence of the divergences and the convergence, which appear between the equatorial currents, is clearly reflected in the distribution of particles.

G 4

# Circulation and Tidal Currents underneath the Shelf-ice, Queen Maud Land

By

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Observations of temperatures and salinities and measurements of currents were made from the chartered vessel of the Norwegian-British-Swedish expedition to the Antarctic, the "Norsel", when the vessel was moored to low shelf-ice. The depth to the bottom was 404 m. At a short distance from the place of observation the total thickness of the shelf-ice was about 205 m with about 38 m above the water line and 167 m below.

At depth down to 200 m the observations showed lower salinities than observed by earlier expeditions at short distances from the shelf-ice, indicating melting of the ice.

Five 28-hourly series of current measurements at three depths showed currents running towards the west, parallel to the general direction of the shelf-ice and was decreasing towards the bottom. At a depth of 150 m the current had a small component towards the north and at 340 m a small component to the south.

The tidal currents were mainly diurnal. Two series of measurements at 150 m gave widely different results, but one series at 220 m and two at 340 gave results in mutual agreement. The dominating diurnal component turned counterclockwise whereas the smaller semi-diurnal component turned clockwise.

G 6

# On the Fluctuation of the main Stream Axis and its boundary Line of Kuroshio

By

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Adopting the median line of the zone of the strongest flow for the main axis of Kuroshio, we plot the zone of the strongest currents on the dynamically computed current-charts for the years from 1936 to 1943. Also the breadth of the strongest currents are taken for the breadth of the Kuroshio Stream. Moreover, we indicate the boundary line of water-masses by plotting the points of maximum horizontal gradient of surface water temperature and the zone of the highest water temperature $\Theta$ max at the sea surface which lies approximately on the zone of the maximum gradient of the water temperature at the section. Since the stream-axis lies nearly along $\Theta$ max we may take that the latter approximately represents the former.

Also the yearly variation of the distance of the stream-centre from the coast with breadth of the Kurioshio warm current and $\Theta$ min at 200 m depth on the section are plotted.

Inspecting these figures, we recognize that the Kuroshio Current in the period from 1937—1942 flews far off the Kii Peninsula, especially in the years 1938—39 when it was farthest from the shore and that the secondary maximum occurred in the year of 1941. Since after about the years 1942—43 the Kuroshio has shown the tendency to approach the coast and to recover its intensity gradually.

Before the occurrence of the anomalous state of Kuroshio, the dominant inflow from the sea to the south of Kyūshū and

also the development of the vertical current area of the warm water mass A (anticyclonic vortex, its center lying at about 30° N, 134° E) could be found.

Accompanying the development and the decay to vanishing of the anomalous cold watermass B off Kii Peninsula, an anomalous condition of Kuroshio has appeared, and after gradual setting down, it regained the normal state.

The centre of the A-water mass was displaced to the NW area at about the middle period of the anomaly or in some 1938 and 1939, and later about in 1941 and 1942 moved to the area to SE.

Near the end of the anomalous period of Kuroshio the A-water mass deformed to become flat, elongated in EW direction and degenerated in smaller and smaller. In accordance with the easterly translation of its centre the inflow from the area to the south into the Kuroshio Stream decreased. Also the area of the B-water mass (cyclonic vortex) lies to the east of Hachijo Island. During the anomalous period of the Kuroshio, after flowing around the area to NE of the vortex A and coming to S of vortex B, this stream diverges and branches off to S and to N, of which the latter flows to NE around the vortex C. Consequently the amount of the Kuroshio decreases considerably. Accompanying the broadening of the area of the cold water mass B, the transport of the Kuroshio decreases and its path shifts to east and south. It coresponds to the decay of the Kuroshio. However, as the distance of the stream axis from the coast increases, the current velocity increases proportionally. The breadth of the Kuroshio is about 20—60 sea-miles and mostly about 30—50 sea-miles. The current velocity tends to increase as the breadth of the Kuroshio decreases.

In the winter and spring of 1938 the anomalous state of Kuroshio attained nearly to its flourishing maximum and corresponded to the most expanded cold water area B At the same time the breadth of the Kuroshio became broader than usual *i. e.* to about 50 sea-miles. In general inspecting the distribution of the current velocity in the anomalous period of the Kuroshio, the current flow is most conspicuous in the eastern portion of the Kuroshio.

The appearance of the cold water mass B consisting of the upwelled water of the Subarctic Intermediate Water comes later

than the occurrence of maximum intensity of the cold Oyashio Current in the region to NE of Japan. Thus we may conclude that the phase of the growth and decay of the cold water mass B is a phenomenon essentially different from that of the cold coastal water.

It is considered that the stronger monsoon in the winter of 1934 and 1935 surpressed the intensity of the NE-ly-going Kuroshio in the regions to the south of Kagoshima Pref. and to the west of Ryūkyū Is. by sweeping the sea surface, and conversely it accelerated the intensity of the E-ly-going Kuroshio in the regions south of Honshū by blowing on the sea surface from W and NW direction. It is concluded that the continuity of the amount of flow between the two regions above cited does not agree so that the inflow from the south together with the coastal upwelling must subsequently occur.

G 6.1 (H 3)

# A Computation of Surface Current Velocities in the Mid-Pacific from Wind Stress Data

By

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During the last four years the theory of ocean currents has made a remarkable progress, especially by the work of SVERDRUP, STOMMEL, MUNK and HIDAKA. This work was, however, mainly concerned with calculations of mass transports and not of velocities. Such a treatment has the great advantage of being independent of the vertical density distribution and of the internal friction between the water layers at different depths.

On the other hand, it seems desirable, for a better test of the theory and of the assumed wind stress values, to compute also surface velocities and not only mass transports, because we have at our disposal a large number of surface velocity observations (derived from ships' displacements), whereas transport data are rather scanty. This is especially true for the Pacific. The present computations covered the Eastern Equatorial region of the Pacific Ocean, a region where according to SVERDRUP (1) lateral mixing can, in first approximations be neglected.

The velocities were computed by means of a super-position of the classical formula for the wind-drift-current (EKMAN) and the gradient current; with the east- and north-components of the vectors represented as the real and imaginary parts of complex quantities, the formula for the surface current becomes:

$$s\,(o) = \frac{\tau}{\varrho_o \nu \sqrt{i\alpha}} - \frac{\beta_o}{i\alpha} \qquad \text{(I)}$$

where $s\,(o) = v_x\,(o) + i\,v_y\,(o)$
$v_x\,(o)$ = east component of the surface velocity ·
$v_y\,(o)$ = north » » » »
$\tau = \tau_x + i\,\tau_y$
$\tau_x$, $\tau_y$ the east and north component of the wind stress at the sea surface, respectively.

$$a = \frac{\lambda\, i}{\nu}$$

$\lambda$ = Coriolis parameter
$\nu$ = kinematic eddy viscosity

$$\beta_o = \frac{1}{\varrho_o\,\nu} \cdot \left(\frac{\partial\, p}{\partial\, x} + i\,\frac{\partial\, p}{\partial\, y}\right)$$

$\varrho_o$ = density in the surface layer
$i = \sqrt{-1}$ = imaginary unit
$\frac{\partial\, p}{\partial\, x}$, $\frac{\partial\, p}{\partial\, y}$ = east- and north-component of the horizontal pressure gradient in the isothermal layer.

The computations were based upon the assumption of a type of density distribution proposed by REID (2) and consisting of a homogeneous layer of thickness $h$ beneath which the density increases with depth proportionally to exp. $\left(1 - \frac{z}{h}\right)$. The pressure gradient $\beta_o$ was computed from the vertically integrated pressure gradient $\nabla P$ by means of the relation

$$\beta_o = \frac{2}{5\,\varrho_o\,h\,\nu} \cdot \left(\frac{\partial\, P}{\partial\, x} + i\,\frac{\partial\, P}{\partial\, y}\right)$$

in which $\frac{\partial\, P}{\partial\, x}$ and $\frac{\partial\, P}{\partial\, y}$ may be expressed as functions of the wind-stress-field only, according to the theory of mass transport; $d$ is the depth below which the water is assumed to be at rest. The wind stress data were the same as those used by REID (3) in his paper on the equational currents of the Eastern Pacific as maintained by the stress of the wind. The eddy viscosity (assumed to be constant with depth) was computed by means of the relations between the eddy viscosity and the wind velocity W proposed by THORADE:

$$\begin{cases} \nu = 1.02\,W^3 & (W < 6 \text{ m/sek.}) \\ \nu = 4.3\,W^2 & (W > 6 \text{ m/sek.}) \end{cases}$$

In a narrow belt on both sides of the equator the above formula (I) is no longer applicable, since the more one approaches the equator, the more important becomes friction within the gradient current in comparison with the Coriolis force, while in the classical formula friction has been neglected in the gradient current. As a consequence formula (I) gives an infinite value of s(o) at the equator. For an arbitrary density distribution, if only stable, below a homogeneous layer of thickness $h$, the correct expression for the surface velocity (again in complex notation and now including friction in the gradient current) becomes:

$$s(o) = \frac{\tau}{\varrho_o \nu \sqrt{\alpha}} - \frac{\beta_o}{\alpha}\left(1 - e^{-\sqrt{\alpha}\, h}\right) - \frac{K}{\sqrt{\alpha}} \qquad \text{(II)}$$

with $K = \int_h^d \beta\,(z)\, e^{\sqrt{\alpha}\, z}\, dz$ ($d$ = depth of no motion).

It is obvious, that this formula approaches the "classical" formula rather rapidly when $|\sqrt{\alpha}\ h|$ becomes large, which occurs when we are outside a narrow belt (wide about 2 degrees of latitude) on both sides of the equator.

At first sight, formula (II) seems to give also infinite values for $\alpha = 0$, but from the relation which the theory of mass transport has shown to exist between wind stress, integrated pressure gradient and mass transport, it can easily be shown that the surface velocity does not become infinite when computed with formula (II). In fact, for the surface velocity exactly at the equator we obtain:

$$s(o) = \int_o^d z\, \beta\, dr$$

for an arbitrary density distribution. For the density distribution proposed by REID this becomes:

$$s(o) = 4\, \beta_o\, h^2$$

The computed surface currents were in fair agreement with the currents computed from ships' displacements, at least as to their directions. The magnitudes, however, were about twice as small as they should be. This discrepancy can be accounted for by altering the "roughness factor" in the relation between wind velocity and wind stress in this sense, that the relation becomes

$\tau = 2.10^{-6} W^2$ (c.g.s.) for winds less than about 4 Beaufort. This is appreciably more than has previously been assumed for light winds. From MUNK's (4) computations of the mass transport of the Gulf Stream a similar conclusion may be drawn.

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# Papers on Waves

G 7

## Forme et Energie de l'Onde Maree de Vive-eau entre les Heaux de Brehat et le Cap de le Hague

Par

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L'emploi des mesures de courant dans la recherche de la forme prise par l'onde marée est devenu classique dans les études théoriques. Cette communication apporte une contribution pour un domaine restreint dans la région de la Manche oú les marées ont le marnage maximum.

La pente de la surface est obtenue en exprimant que la colonne élementaire située au poste d'observation de courant est en équilibre sous l'action des forces d'inertie proportionelles à $\frac{d\vec{V}}{dt}$, des forces de pression proportionnelles au gradient de $\zeta$ et des forces de Coriolis. Etant donnée la complexité des pertes par frottement dans une région de relief aussi compliqué, la perte de charge correspondante a été négligée dans les calculs; les nombreuses observations de marées sur la côte française et dans les îles anglo-normandes ont permis de redresser les inexactitudes qu'entraîne cette approximation.

L'énergie transmise à travers une section verticale comprise entre le fond et la surface est mesurée par le flux à travers cette

section du vecteur $(g\zeta + \frac{1}{2} V^2) \vec{V}$, le premier terme $g\zeta$ se rapportant à l'énergie potentielle transmise, le deuxième terme $\frac{1}{2} V^2$ à l'énergie cinétique. L'amplitude de la marée, l'amplitude du courant et la différence de phase entre ces deux éléments influent sur la valeur de l'énergie totale transmise. Le bilan pour une période de la marée fait ressortir dans un domaine fermé un résidu qui correspond au travail des résistances passives; il mesure l'importance des pertes par viscosité, turbulence et frottement sur le fond.

Une puissance moyenne de $52.10^6$ kilowatts pénètre dans le Golfe de St. Malo entre Bréhat et Guernesey; la majeure partie $35.10^6$ kilowatts passe entre Jersey et Guernesey tandis que $10.10^6$ kilowatts passent entre St. Malo et Jersey; la différence, $7.10^6$ kilowatts est dissipée par frottement à l'intérieur. Les 10 millions de kilowatts qui entrent dans le passage de la Déroute se partagent en deux parties égales: une moitié s'échappe vers le nord entre Jersey et Carteret tandis que l'autre moitié est dissipée par frottement. Les 40 millions de kilowatts qui pénètrent par le sud dans le pentagone Jersey-Guernesey-Aurigny-Cap de la Hague-Carteret donnent $28.10^6$ kilowatts à la sortie du Raz Blanchart tandis que la puissance moyenne transmise entre Guernesey et Aurigny est approximativement nulle: $12.10^6$ kilowatts sont dissipés par frottement à l'intérieur du pentagone.

La puissance moyenne dissipée par frottement dans le domaine entier est d'une vingtaine de millions de kilowatts. Cette puissance représente 20 % de la puissance efficace mise en jeu par la marée à l'intérieur du domaine. Les valeurs adoptées habituellement pour le coefficient de frottement ne permettent pas d'expliquer le niveau élevé de la puissance dissipée: cela est dû aux pertes singulières causées par les hauts fonds au-dessus desquels à certaines heures de la marée, la profondeur d'eau atteint la hauteur critique: un régime d'écoulement avec ressauts s'établit et la dissipation d'énergie s'y trouve sensiblement accrue.

G 10

# Further Investigations of North Sea Surges

By

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Several investigations have been made recently of the disturbed levels in the North Sea during large and specially selected storms.

The object of the investigations has been to get a picture of the water movements inside the North Sea and of the way in which these movements are produced in the course of a storm, and to determine, so far as possible, for typical disturbances, from a comparison of maps of co-disturbance lines and the simultaneous meteorological conditions drawn at frequent intervals, the important centres and areas of origin of disturbance, the relation between the water gradients and the winds or pressure gradients, the extent of the flow of water into or out of the North Sea, the positions and movements of nodal lines and the effect of the earth's rotation.

The first disturbance examined was that of 8th January, 1949, when near Kings Lynn on the east English Coast the level was raised by approximately six feet; the results of this investigation were published in 1950. (Phil. Trans. Roy. Soc. No. 853. Vol. 242.)

Perhaps the most puzzling type of surge which has been encountered is what we now call an "external surge". External surges seem to be generated outside of the North Sea, though they are not connected in any obvious way with the winds immediately to the north of the North Sea. They are usually generated when a deep depression moves north-east between Scotland and Iceland and have been shown (Corkan, H. O. Misc. 15072, Washington, D. C., 1948) to be closely related to the pressure changes along the shallow Wyville Thomson Ridge which joins the two

countries. Attempts to account for them using the theory for a travelling depression (Proudman, M.N.R.A.S. Geophys. Suppl. 2, 1929) have not been successful, but the magnitude of the disturbance has been shown to be larger when the centre moves steadily on, than when it hesitates when over the ridge. There is also a fairly consistent interval of 14 hours between the time of greatest rise at Dunbar and the time of minimum pressure at the Faroes.

Inside the North Sea external surges travel down the western North Sea like progressive waves, the progression being similar to that of the tide.

Doodson (Geophys. Mem. no. 47, 1929) traced disturbances all round the North Sea, though his examples were probably largely generated inside the North Sea. Hitherto little has been known in detail of the progression of external surges along the coasts of the continent.

One important conclusion from the recent investigation was that certain surges may be accompanied by large transports of water out of and into the North Sea. This immediately leads to the suggestion that external surges may result from an earlier outflow produced during a storm when the level has been lowered. Surges of external origin are frequently preceded by a large lowering of level with strong southerly winds over the North Sea and to the north. The external surge arrives when the wind moderates, which it may do with little change of direction.

Ljundahl (Stormfloden i Skagerrack—Kattegat den 4. December 1914, Svenska Hydrografisk-Biologiska Kommissionens Skrifter, 1921) previously suggested from statical considerations that a large depression centred north of the North Sea would itself give rise to a large accumulation of water which he visualized would travel away from the centre of the depression, like a progressive wave, when the depression moved off.

In the case of the storm of 8th January, 1949, external effect, as indicated by the disturbance which travelled down the western North Sea, was comparatively small.

Recently, two additional storms, those in which, between 1928 and 1938, the observed external effect was greatest have been examined. In the first example the winds over the North Sea became nearly negligible and we can follow a large disturbance of level of the order of five feet progressing counter-clockwise

around the North Sea and showing features which in certain ways resemble those characteristic of the free oscillations in a rotating rectangular basin (Taylor, Proc. Lond. Math. Soc. 20, 1920).

There is a secondary progression into the Thames Estuary.

In the second example the earlier phases are perturbed by winds over the eastern North Sea but very soon the same characteristic features become prominent.

There is little indication of a continued oscillation.

G 10.1

# Storm Effects in the Irish Sea

By

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During the past year the disturbed levels in the Irish Sea and its approaches during five specially selected storms have been determinated from the tidal observations at all possible stations around the coast.

Conclusions from the five typical storms examined are as follows:

When the winds are localised over the Irish Sea estimates of the frictional constant, on the assumption that the tractive force varies as the square of the wind velocity, are in general agreement with similar determinations made elsewhere.

Localised northerly winds over the Irish Sea tend to lower the level of the sea as a whole, the smallest lowering being at Liverpool.

Strong southerly winds may occur near the southern entrance to the Georges Channel with very little disturbance at stations like Cork and Newlyn, and are followed, after several hours, by a raising of level in the Irish Sea.

When a depression is widespread south of Ireland with strong southerly winds of appreciable duration over the whole of the Bay of Biscay, the level over the whole region inside a line joining Cork to Newlyn may be raised one to two feet with only minor variations from place to place.

G 10.2

# Wave Generation

By

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Continued analysis of wave records from the coast of Cornwall, supplemented by observations for short fetches in the Irish Sea and Lough Neagh, has afforded fresh evidence that the development of a wave pattern is resolvable into the growth of a spectrum of waves, the upper limit of wavelength being determined by the greatest wind strength. The shorter waves which dominate the wave pattern when the wind is light grow higher till they reach a limiting steepness at which they lose energy as fast as they gain it. In equilibrium conditions — after a fetch of 100—200 miles — the limiting steepness appears to depend inversely on the square root of the wind speed. An attempt is being made to explain such conclusions in terms of the probable stresses exerted by the wind.

G 11

# Note on the Effect of surface Films on Ripples

By

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Extending a calculation given already in the text-book "Hydrodynamics" of *Lamb* (1932), the complete linearized theory of the decay of surface waves on water by friction, if a surface film is present, is elaborated. The theory includes the effects of a limited compressibility of the film (*i.e.* variation of surface tension with area available for a certain part of the film), of a notable "surface viscosity", and of a hysteresis in the surface tension. These effects appear linearly combined together in one complex parameter $a$.

Without surface film, $a$ is zero, and the modulus of decay (as defined by the time in which the amplitude of a wave has decreased by a factor $e^{-1}$) is given by $\tau_1 = (2\nu k^2)^{-1}$ (with $2\pi/k$ = wave-length and $\nu$ = kinematic viscosity of water). If the modulus of $a$ exceeds a certain value, the modulus of decay is practically given by the value $\tau_2 = 2^{3/2} k^{-1} (\nu\sigma)^{-1/2}$, (where $2\pi/\sigma$ = period of wave), which corresponds to $a = \infty$; in this case the horizontal motion at the surface is practically annulled by the film. For a wave-length of 0.1 cm, $\tau_1/\tau_2$ = ca. 2, for 1 cm: ca. 3.5, for 10 cm: ca. 14.

For capillary ripples with wave-lengths between 0.1 and 2 cm, a very slight dependence of surface tension on available surface area appears to be already sufficient to make $\tau \approx \tau_2$. This indicates that a large variety of surface films is capable of causing the increased decay.

It seems evident that the rather moderate increase of decay of capillary ripples by the presence of a surface film cannot be put responsible for the apparent effect of oil on wind-waves, but that the essential thing must be here the prohibition of relative

horizontal velocities at the surface, which prevents the arising of wind-induced irregular movements along the surface. This idea has already been suggested as early as 1883 by *J. Aitken,* who made a number of elucidating experiments on the subject.

A consequence of this concept is that the turbulent *skin* friction exerted by the wind is the essential agent in forming initial capillary ripples on clean water surfaces.

G 12

# Measurements of internal Waves

By

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In a paper "Interne Wellen" (Geof. Publ. Vol. X No. 6, Oslo 1933) I gave a theory of internal waves in a sea where the density varied continuously with depth. It was shown that an infinite number of solutions could be found, corresponding to waves of the same period, but different velocities of propagation.

To test this theory some measurements were made in Herdlafjord near Bergen in the summer 1934. Three different stations were occupied successively. Measurements of temperature and salinity were made at different depths, and at the same time current measurements were made in order to determine the tidal currents.

The temperatures and the salinities showed quite large variations of tidal period which could be explained satisfactorily by assuming that they were composed of four internal waves. The amplitudes of these waves could be calculated from the density variations.

The theory then made it possible to calculate the current, which could then be compared with the observed values. From the theoretical velocities of propagation it was then possible to compute vertical oscillations and tidal currents at the two other stations and compare the results with the observations.

It was found that the phase angles, computed in this way, corresponded fairly well with the observed phase angles, but that the computed amplitudes were greater than observed. Since the observations at the three different stations were not simultaneous, it was impossible to ascertain if the diminution of the amplitudes

was caused by the configuration of the fjord alone or if the friction should also be taken into account.

In the summer 1949 I had an opportunity to repeat the observations with two vessels simultaneously. Conditions were much the same as those encountered in 1934, and a similar program was carried through. The two vessels were anchored 11 km apart. It was found that the tidal currents were small except in the upper 15 to 20 meters. The variation of temperature and salinity indicated large internal waves of a progressive type.

In the following table the results of the harmonic analysis of the density variations are given for the two stations.

Table I.

| *Depth* | $\sigma_\tau$ | $\varkappa_I$ | $\sigma_\tau$ | $\varkappa_{II}$ |
|---|---|---|---|---|
| 5 | 0.423 | 78° | 0.333 | 210° |
| 10 | 0.304 | 56° | 0.139 | 213° |
| 20 | 0.189 | 74° | 0.094 | 191° |
| 30 | 0.138 | 80° | 0.041 | 185° |
| 50 | 0.048 | 68° | 0.021 | 211° |
| 100 | 0.006 | 61° | 0.002 | 168° |

The results of the current measurements are given in Table II.

Table II.

| *Depth* | $\vartheta_I$ | $\varkappa_I$ | $\vartheta_{II}$ | $\varkappa_{II}$ |
|---|---|---|---|---|
| | cm/sec | | cm/sec | |
| 0 | 11.3 | 260° | | |
| 5 | 14.5 | 280° | 6.6 | 29° |
| 10 | 13.2 | 275° | 6.6 | 51° |
| 15 | 12.4 | 264° | 6.6 | 65° |
| 20 | 5.5 | 254° | 5.3 | 80° |
| 30 | 3.4 | 204° | | |
| 40 | 4.0 | 231° | | |
| 60 | 1.3 | 179° | | |

As will be seen from the table giving the density variations there is a phase difference of some 130° between station II and

station I, which corresponds to a time difference of 4.4 hours. Since the distance between the two stations is 11 km the mean velocity of propagation will be 69 cm/sec.

The current measurements in the same manner indicate a phase difference of some 148°, corresponding to 5.1 hours. This would give a mean velocity of propagation of 60 cm/sec.

By means of the theory a more detailed discussion of the observations can be given.

The tidal currents are concentrated in the upper layers. This is caused by the bottom configuration of the fjord and it is probable that this variation of the current with depth is the cause of the vertical oscillations of the water strata.

G 13

# Theoretical Investigations of North Sea Surges

By

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A fundamental type of surge in the North Sea, classified by Corkan in his researches as Type E′, is that associated with the eastward passage of an atmospheric depression either across the northern entrance to the North Sea, or across the area slightly to the north.

In the present investigation such a depression is assumed to pass across the open entrance to a rectangular sea, the surface of which is otherwise undisturbed. The hydrodynamical equations then give the resulting motion of the water. The equations are simplified by assuming only longitudinal waves, with sensibly horizontal motion, and a consequent simple frictional law. The results reproduce the main features observed in such surges in the North Sea and it is possible to deduce the conditions under which such disturbances become large.

G 13.1

# Tidal Work in India

By

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Tidal operations in India have mainly been, from the very beginning, the responsibility of the Survey of India. The earliest recorded tidal observations in India were those carried out by James Kyd at the Kidderpore Docks, Hooghly River, during 1806—27. Some observations have subsequently been taken at certain other ports by independent observers, and for some places (*e.g.*, Bombay, Calcutta, Madras) even some tide tables appear to have been published; but systematic tidal operations cannot be said to have started in India till about 1879 when the general control and superintendence of tidal observations were entrusted to the Survey of India Department.

2. Systematic tide-gauge observations have been carried out at some time or the other by the Survey of India at about 42 standard ports between Suez and Singapore in the Indian Ocean, the normal length of observations at each port being about 5 years. In the case of certain major ports observations have continued to be taken from the very beginning (from about 1879) to date, but in a majority of cases the observations were discontinued towards the end of the last century as soon as the necessary data for tidal predictions had become available.

3. For prediction purposes, a harmonic tide predicting machine with 24 components was constructed for the Government of India in 1879 and was set up in the Stores Department, Lambeth, London, and later on at the National Physical Laboratory, Teddington. The necessary data used to be supplied from Dehra Dun (the Office of the Goedetic Branch, Survey of India) and the tide tables used

to be prepared and published in England till 1921, when the machine was brought over to India and set up at the Geodetic Branch, Survey of India, Dehra Dun. The entire work of observations and their reductions and the preparation and publication of tidetables for the Indian Ocean has since been the concern of the Survey of India.

4. The main publication containing the India Tide-tables is "Tide Tables of the Indian Ocean" — an annual publication which gives predictions for 67 ports in the Indian Ocean, of which 39 ports lying between Suez and Singapore are predicted by the Survey of India, the remaining being obtained on an exchange basis from the Hydrographic Departments of Foreign countries. In addition to the above publication, three separate tidal pamphlets are also published every year containing separate tidetables for Bombay, the Hoogly River (3 ports) and the Rangoon River (2 ports).

5. For most of the ports, the data on which predictions by the Survey of India are based are over 50 years old. In a number of cases, there is evidence of significant changes in the sea bed, local configuration of the land and in river estuaries, which have an effect of considerable magnitude on the tidal occurrences. It is, therefore, intended to base future predictions as far as possible on fresh observational data. At present, tide-gauges are in operation along the Indian and adjacent coasts only at Aden, Karachi, Kandla, Bombay, Vizagapatam and a few river stations on the Hooghly. It is proposed to establish before long, some more tidal observatories at the various standard ports. In the mean time, a touring Tidal Detachment, recently formed in the Department, has been visiting certain primary and secondary ports and carrying out hourly observations on tide poles for about a month from which a preliminary assesment of changes in the tidal regime at the various standard ports can be made, and priorities for tide-gauge observations can be assigned. These observations are also of considerable importance in certain areas of interest where inferred constants only have so far been used for predictions.

6. The overhauling of the methods of tidal analysis and predictions now being followed in the Survey of India, is also in hand. The older B.A. method of harmonic analysis was discontinued about 30 years ago for all ports at which three year's observations

had been analysed, as it was not considered comprehensive enough to yield the desired accuracy. It is now proposed to adopt the latest method of analysis for all future work.

7. Again in respect of riverain predictions a combined harmonic and non-harmonic method has hitherto been followed in the Department and this has been found from experience to be far from satisfactory. The latest Liverpool Institute's method of predictions catering for harmonic shallow water corrections is now going to be adopted, and a number of riverain ports for which modern data are available have already been brought on to this new method. A new machine with 42 components is proposed to be installed shortly. This machine, amongst other innovations makes provision for harmonic shallow water constituents for riverain ports. It is hoped that the revised methods and the use of a new machine with more components will lead to a substantial improvement in the quality of the Indian predictions.

8. The harmonic analysis of observations having been suspended since 1920, pending the adoption of a more intensive method than the one followed so far, a lot of valuable observational data in the form of tide-gauge records for certain ports has accumulated but it has not been possible to use it for any systematic work on M.S.L. valuations or tidal analysis. Some computations of M.S.L. have been carried out in connection with the supply of data to the International Association of Physical Oceanography for printing in their "Publication Scientifique" but some of the values could only be computed from high and low waters instead of rigorously from the hourly heights. The situation as regards the progress made up to date is explained in detail in Chapt. VIII, Survey of India Technical Report Part III, 1948—49. It is hoped to take up the work of M.S.L. computations in the near future.

9. Oceanographic activities in India, in so far as off-shore surveys and echo-soundings are concerned, are carried out by the Marine Survey of India. The Survey of India and the Marine Survey Department are in close liaison with each other regarding their coastal programmes and tidal observations.

G 14

# La Diffraction de la Houle. Solution pratique Approchee

Par

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KIRCHOFF, appliquant la formule de GREEN à la fonction de propagation d'une onde à trois dimensions et à celle d'une onde sphérique, a donné une justification classique du principe d'HUYGHENS.

Pour une onde à deux dimensions, à laquelle on peut ramener la houle, on obtient une formule analogue, mais moins simple pratiquement, car l'onde de surface rayonnant d'une petite zone comporte des fonctions de BESSEL d'ordre zéro de première et deuxième espèces au lieu de l'expression $e^{-ikr}/r$ de l'onde sphérique. Remplaçant ces fonctions par le premier terme de leur développement, on obtient l'énoncé d'un principe d'HUYGHENS adapté à la houle, en incidence quelconque et, moyennant diverses hypothèses, l'expression de l'agitation au voisinage d'une jetée semi-indéfinie ou d'une brèche dans une jetée.

L'agitation s'obtient, dans les cas cités, en relevant la distance entre les points de spirales, tracées une fois pour toutes, et analogues à la spirale de CORNU introduite dans l'étude classique de la diffraction optique. Les paramètres déterminant ces points sont liés de façon simple à la position, par rapport aux musoirs, du point ou l'on cherche l'agitation et se lisent sur un réseau de paraboles tracées une fois pour toutes.

Des formules asymptotiques simples aident dans beaucoup de

cas pratiques. Les résultats obtenus par cette méthode semblent voisins de ceux qu'ont donnés divers essais sur modèle réduit.

La solution proposée n'a pas d'intérêt théorique spécial puisque, dans les cas cités, la solution théorique exacte a été trouvée, mais elle nous paraît avoir un intérêt pratique appréciable en raison de sa simplicité.

G 15

# Estimated Damage along the Pacific Coast of Japan due to probable future Tsunamis

By

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During the period from 520 B. C. to the present time, Japan has suffered from approximately 80 tsunamis of major importance. Of these, 65 occurred on the Pacific coast and the remaining 15 along the Japan Sea coast. These tsunamis have been classified into five ranks from M 0 to 4 depending on their magnitudes. The author has found that the total energy emitted from the origin in any tsunami may be expressed by the relation, log E 21.39 0.6 M, wherein M is the magnitude of the tsunami. The sum of the total energy emitted by major tsunamis during past 350 years has been calculated to be about 4.24 10 ergs or approximately 1.21 10 ergs per 100 years.

Assuming that the rate at which the energy of tsunami emitted in the future will be the same as during the past 350 years, the author has computed the amount of energy expected to be emitted from any given portion of a seismic zone down to the 200 meter isobaths around Japan and the probable amount of energy which will be transferred during the next 100 years through any given vertical section alorg 200 meter isobath.

The energy of any tsunami, after crossing the 200 meter isobath at right angles, will be distributed to each coastal village in a definite proportion depending on the topography of the zone between the 200 meter depth and the shore line, but irrespective of the tsunami origin. This topographic factor is denoted by T(P).

The author has determined the values of T(P) for almost all

villages on the Pacific coasts of Japan except for Hokkaido. We may estimate, therefore, from the computed values of T(P) and the amount of energy which will cross the 200 meter isobath, the energy of tsunami that may be expected at each village on the Pacific coast during the next 100 years, and likewise the maximum height of tsunami waves during the same period.

Since the damages due to any tsunami may be considered to be proportional to its energy, or to the square of the wave height, the computed values may serve as a measure of the degree of danger to be caused by future tsunamis at each village.

The full paper will be published in the *Bulletin of the Earthquake Research Institute, Vol. XXVIII, No. 3—4.*

G 17

# Energy-supply to Wind-generated Waves

By

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The aim is checking the energy-balance of wind-generated waves: $\partial E/\partial t = R_N + R_T - W_I - W_B$.

In the wind-flume of the hydraulic laboratory at Delft, 4 m in width, measurements have been made on a wave generated by a wind of 11 m per second, over a fetch of 50 m at a depth of 0.35 m.

The wave is 1.2 m long, 0.10 m high, and has a clearly asymmetric shape. The average tangential stress, $\tau_0$, between air and water has been deduced from the observed loss of energy of the air-current — after correction for friction along the sides and the roof of the flume.

A paraffine copy of the wave was placed in an other flume, through which water was made to flow. The pressure along the surface of the wave has been measured, as well as the velocity of the water in verticals at the crest and at the trough of the wave. In this way sufficient data have been collected, from which could be calculated the energy which is transmitted to the wave by normal pressure and by tangential stress ($R_N$ and $R_T$ respectively). The wave is still growing. Its dimensions agree with the diagram in Proceedings Oslo 1948 by the author (extension of Sverdrup's diagram Trans. A.G.U. 1946). The accretion of energy, $\partial E/\partial t$, can be computed by means of the same diagram and is smaller than $R_N + R_T$. The difference represents the work done by internal friction, $W_I$, together with friction along the bottom, $W_B$.

The value found is quite acceptable.

From the distribution of the velocity of the wind in a vertical the roughness-value of the waves in the logarithmic velocity-formula can be deduced.

G 17.1

# Surf Beats

By

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Surf Beats as reported by Munk to the 1948 conference in Oslo have been examined off the coast of Cornwall. Long waves with periods of 2 to 3 minutes, and a few inches in amplitude, were measured by a wave recorder approximately 1 000 yards offshore in a sounding of 44 feet, and it was shown that they are due to the varying height of groups of waves approaching the beach. The amplitude of the long waves was found to be approximately proportional to the amplitude of the ordinary waves and independent of their period. The mechanism by which they are produced has been discussed.

G 18

# On the Ocean Wave Spectrum, with special Reference to the Beat Phenomena and the "1-3 Minute Waves"

By

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The oscillations of the near-shore water level with 1—3 minutes' period, discussed in 1949 by W. H. Munk, have been often found in tidal records and sometimes in wave records in several parts of our country.

The present paper deals with the problems why the ocean waves, sea and swell, usually in beat with 1—3 minutes' period, and why the "1—3 minute waves" occur so frequently. These phenomena will be explained from a stand point of the spectrum-structure of waves in the ocean. The results of the present theory show that these oscillations may occur when the major part of energy is concentrated within a comparatively narrow and finite interval of about 1—3 sec. around the significant wave period in the spectrum.

Such a distribution of energy in the spectrum may be expected from various physical points of view and also supported by the actual evidences in spectrograms. The occurrence of the beats with 1—3 minutes' period under the circumstances will be understood as the interferences of component waves, while the origin of the 1—3 minute waves may be in the non-linearity of the high-wave-systems, analogously to the "compound tides" and "combination tones". The theoretical results suggest that the latter may

be generated in the open ocean as well as in the surf zone, and that the occurrence with their particular periods in many localities will depend on the general structure of the ocean wave spectrum or the characters of the wave-generating storms.

# Papers on Turbulence

G 19

## Some Observations of Turbulence in a tidal Current

By

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Oceanography Department, University of Liverpool

A number of observations have been made in the Mersey Estuary of fluctuations in the speed of the tidal current, using the Doodson electrically-recording current meter, which was designed for this purpose and which responds to all fluctuations with periods greater than about 1 second. Many records were obtained with the current meter in a stand on the bottom and others were taken with the meter suspended at various depths. In a second series of observations, two current meters were supported in the stand, with different vertical and lateral separations.

When the meters were suspended freely near the surface or at mid-depth, the oscillations of current due to surface waves were often appreciable. The fluctuations observed with the meters in the stand, within 1 or 2 metres above the bottom, however, were greater in amplitude and different in character. The analysis has shown fairly conclusively that these fluctuations are due to turbulence. The root mean square value of the fluctuations averages 12 % of the mean current at that depth.

The periods of the turbulent fluctuations vary from a few seconds up to several minutes. Various methods of analysis have failed to show any predominant periods or bands of periods within this range, and it appears that, as in other types of turbulence,

a continuous spectrum of fluctuations is present. Auto-correlation curves have been derived from many of the records and, on certain assumptions, these may be related to the longitudinal distance-correlation of the fluctuations. The integral scale of the turbulence, as usually defined, is estimated to be of the order of 7 metres, compared with 14 metres, the depth of water.

From the simultaneous recordings of two current meters, estimates have been obtained of the vertical and lateral distance-correlations of the fluctuations. Both these correlations appear to be of the same order of magnitude. Typical values are 0.65 for the coefficient of correlation between the fluctuations at the two meters separated by 76 cm laterally, and 0.53 when they are separated by 84 cm vertically.

G 20

# The Modification to Knudsen's Hydrographic Theorem required by mixing along the Current

By

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In the form applicable to the flow of sea water through a channel, Knudsen's hydrographic theorem gives a relation between the salinity and mean rate of flow at the end sections and the net rate of addition of fresh water within the channel. It is valid if the effects of transport of salt across the end sections by horizontal mixing are negligible compared with the effects of transport by advection. An attempt made recently to repeat Knudsen's determination of the mean flow through the Irish Sea has indicated that in this case the above assumption is not justified.

In addition to the two end sections, across the southern entrance and the North Channel, respectively, two intermediate sections were taken, Carnsore Point — St. David's Head and Dublin—Holyhead. The Sea was thus divided into three regions and Knudsen's method applied to each in turn. There are large discrepancies in the two independent determinations of the rate of flow across each of the two intermediate sections obtained in this way. It is concluded that the effects of turbulent mixing in the southern entrance and the North Channel, which have hitherto been neglected, are in fact comparable with the effects of advection.

If only the central part of the Irish Sea, bounded by the two intermediate sections, is considered, the effects of mixing are probably much smaller. On this assumption the mean rate of flow in this region is found to be only about $^1/_3$ km per day, compared with about 1 km per day, the value previously accepted.

The coefficient of eddy diffusion in the direction of the current is estimated to be between $5 \times 10^6$ and $9 \times 10^6$ $cm^2$/sec. in the southern entrance. Since the width of the entrance is about 300 km, this value agrees in order of magnitude with the empirical relation given by Munk, Ewing and Revelle, who have found that the coefficient of horizontal diffusion lies between 0.2 r and 0.5 r, where r is a dimension representing the radius of the area of sea concerned.

G 21

# Notes on Waves and Turbulence

By

P. GROEN

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The interrelations between waves and turbulence may be seen from different points of view, or with regard to different questions, as f.i.:

(a) How are the stratifications which favour those two states of motion, respectively? (b) How does turbulence affect waves, if both are present? (c) How can a wave state develop into a state of turbulence? (d) Can an initially purely turbulent state of motion develop into a wave state?

It may immediately be seen that the same questions can be put with regard to convection "cells" and turbulence.

In entering upon those questions, the first thing to consider is a general systematics of these three states of motion, which are called waves, cells and turbulence. When doing so, we see that from a formal kinematic point of view they may be described and distinguished with help of the notions "order" and "disorder". This fact suggests that it might be tried to develop also a dynamic theory comprising all three of those states of motion, which would then be special or extreme cases of the general state. The need for such a theory becomes especially clear in considering the last one of the above four questions.

As to question (a), the answer might be briefly summarized as follows:

| Stratification | State of motion favoured |
|---|---|
| Statically stable | Waves |
| » indifferent | Turbulence |
| » unstable | Cells |

Question (b) is especially important with respect to the decay of swell. This problem has been tackled by Groen and Dorrestein from the point of view of the "4/3-law" of turbulence, by Bowden on the more elementary basis of the theory of Reynolds' stresses. Both treatments have certain deficiencies and are in a sense complementary to each other.

Question (c) is easier again. Waves give rise to turbulent motions as soon as they become unstable. Instability of formerly stable gravity waves usually arises from a shortening of the wave length making the steepness increase to a critical value, where a turning over of the waves begins. This is not only the case with surface waves breaking in shoaling water, but also with internal waves running into water layers with a statical stability that becomes gradually smaller. It has been proved both theoretically and experimentally that for a given value of the period the wave length would become zero for a certain critical value of the maximum stability occurring in the water column, if the internal waves would not already have turned over before. This may be an important source of turbulence in certain sea areas.

(d) The development of waves from an initially purely turbulent state of motion is a most important problem, especially with regard to the generation of wind waves.

It is suggested here that the only way to bring this problem to a definite solution is to develop a theory in which turbulence and waves are both incorporated fundamentally. This will be a theory which bears a certain formal resemblance to the order-disorder-theory of statistical mechanics.

G 22

# Bottom Current Fluctuations in the open Sea

By

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Simultaneous records of current velocity at a dozen different levels, from 9 cm to 249 cm above the bottom, have previously been obtained in the tidal current of Alværsund, a narrow channel near Bergen. Similar observations have now been carried out in the open sea, on the Viking Bank, at a bottom-depth of 100 meters and at a distance of more than 100 km from the nearest coast. The instrumental stand was lowered to the bottom from the research vessel of the Geophysical Institute in Bergen, the M/S "Armauer Hansen", anchored fore and aft.

Among other characteristics of the turbulent flow, the records clearly demonstrate an increase in magnitude of the rapid fluctuations when the mean velocity of the current increases.

When postulating a tendency towards equalization within the frequency spectrum of the turbulent flow, and assuming that in the open sea this tendency depends only upon the varying mean velocity, one arrives at an equation similar to the equation of heat conduction. The observations from the Viking Bank are in fair agreement with a solution of this equation.

Also the observations from Alværsund appear to obey the same law. Local turbulent effects from coast and bottom thus seem to dissipate into the normal spectrum over short distances.

# Miscellaneous Papers

G 23

## Note sur les Variations du niveau Moyen de la Mer

Par

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Le phénomène d'ascencion générale du niveau moyen de la mer a été constaté en bien des endroits du globe; on a utilisé ici, pour contribuer à son étude, les observations faites au marégraphe-totalisateur de Marseille, appareil qui a servi à la détermination du zéro du Nivellement Général de la France et qui fonctionne sans interruption depuis le 1er février 1885.

En 1925, M. Prévot, Ingénieur des Ponts et Chaussées, adjoint au Directeur du Service du Nivellement Général de la France, avait analysé la courbe représentative des observations faites au marégraphe. Mais, pour avoir des données étendues sur une période plus considérable, il avait utilisé également les observations antérieures faites à un marégraphe de Brest, admettant ainsi que les variations étaient les mêmes en ces deux points.

L'allure de la courbe de marégraphe de Marseille, depuis 1925, ne s'accorde pas avec les prévisions de M. Prévot. On a donc cherché à voir si les ondes trouvées par M. Prévot figuraient encore dans l'analyse de cette courbe, considérée dans la période 1885—1950.

On trouve d'abord que la courbe oscille autour d'une droite inclinée, et non plus d'une horizontale. Si on cherche à déterminer cette droite, on trouve évidemment que son coefficient angulaire

varie suivant le nombre d'années considéré; en prenant le nombre maximum, on trouve une pente de 1mm, 3 par an.

On retrouve ensuite certaines des ondes composantes déterminées par M. Prévot, en particulier celle de 18 ans 2/3, avec toutefois une amplitude un peu plus faible, mais on ne trouve plus celle de 93 ans, remplacée par la droite moyenne. La durée des observations ne permet pas de préjuger si la variation correspondant à cette droite continuera dans le même sens, ou si cette droite n'est que la tangente à une sinusoïde à inflexion très allongée.

On a cherché ensuite à utiliser les médimarémètres installés sur les côtes de France et d'Afrique du Nord. L'analyse faite pour quelques-uns d'entre eux a montré que ces appareils n'avaient pas une grande précision et qu'il était difficile de déduire de leurs observations les amplitudes des ondes composantes. Par exemple, le médimarémètre A installé dans le puits du magrégraphe donne des écarts avec les résultats de cet appareil.

Il est net toutefois que les amplitudes des ondes composantes ne sont pas les mêmes aux différents postes. Il y a peu d'écart avec le marégraphe aux environs de Marseille, mais, dans l'Océan Atlantique ou la Manche, l'ordre de grandeur de certaines amplitudes est le triple.

On ne peut donc employer la solution qui consisterait à prendre les écarts entre la courbe d'un médimarémètre et la courbe théorique

| Médimarémètres de: | Elévation du niveau moyen en 10 ans |
|---|---|
| — Cherbourg | ÷ 5 mm |
| — Les Sables d'Olonne | 24 |
| — La Pallice | 41 |
| — Biarritz | 4 |
| — St Jean-de-Luz | 2 |
| — Port-Vendres | 17 |
| — Sète | ÷ 4 |
| — Martigues | ÷ 3 |
| — Marseille B | 29 |
| — La Ciotat | 21 |
| — Oran | 26 |
| — Bône | 9 |
| — La Goulette | 0,6 |

déduite de l'analyse de la courbe du marégraphe, et à déterminer la différence de pente entre la droite moyenne du marégraphe et la droite moyenne de la courbe des écarts.

On peut toutefois, pour les médimarémètres ou les observations ont été faites pendant une période assez longue, par exemple une cinquantaine d'années au moins, considérer la droite moyenne de la courbe des observations, qui donne une indication sur le sens de variation du niveau moyen. On verra, d'après le tableau ci-dessus, que des anomalies locales viennent altérer, dans un sens ou dans l'autre, le phénomène général d'ascencion du niveau moyen.

G 24

# Utilisation of total Phosphorus Determinations in Physical Oceanography

By

L. H. N. COOPER

By the method for determining total phosphorus in sea water introduced by Dr. H. W. HARVEY (1948), large numbers of analyses may be made at the average rate of 25 per working day. The precision of the method is high. If polythene storage bottles are used, the samples may be stored indefinitely. The method was designed for studies on the production of organic matter in the sea. It has now been applied in an extensive study of water movements in the Celtic Sea in 1950.

Changes in total phosphorus content of water in shallow seas occur due to:

1) *Partition of phosphorus in stratified water.* In late spring phosphate may be removed from the lighter illuminated surface water by plants which may be eaten by herbivores which in turn form the food of carnivores. By well known processes the bottom water becomes enriched at the expence of the upper layers. Physical agencies, such as wind, may then separate the light and heavy layers, and there is evidence that this separation may amount to hundreds of miles in a few weeks. In August of 1950 the Lowestoft R.V. "Sir Lancelot" found that all the water to the bottom of the English Channel east of 3° W had become very warm, $> 16°$ C. On the basis of S, T & $\sigma_t$ alone this might be attributed to warming up *in situ* of shallow water with strong tidal mixing. The distribution of total phosphorus shows that this was not so, but that this warm water in the Central and Eastern Channel had originated as surface water in the western English Channel, whilst the deeper water there together with much of the pre-

existing deeper water up-Channel had escaped to the westward as a bottom current. In this way the Central English Channel became filled with water strongly impoverished in phosphorus. This issue has so far only been tentatively discussed with Mr. DAVID VAUX who was in charge of the Lowestoft hydrographical programme, and he is not necessarily committed to this view.

2) *Deposition and regeneration of organic mud.* Detrital matter having density little greater than the water may be carried in suspension near the bottom by currents and deposited in areas where currents, particularly tidal currents, are weakest. Regeneration of dissolved phosphorus will be concentrated over such areas of mud (COOPER 1951). The subsequent movement of the enriched water may be followed over sandy or rocky areas where regeneration is weak. Since these areas of regeneration are fixed they can be established once for all.

Total phosphorus content has proved invaluable for establishing divergent eddies where enriched bottom water upwells. One such occurred in the Celtic Sea in April 1950 centred on 50° 20' N, 6° 50' W.

3. *Phosphate contributed by rivers and sewages.* Off the Pembrokeshire coast salinity is reduced by the outflow of the rivers feeding the Bristol Channel. In April 1950 a coastal current flowed westwards along the South Wales coast and turned sharply round St. David's Head into the St. Georges Channel. A similar current flowed south along the Wexford coast around Carnsore Point. The distribution of physical properties would have justified a connection across the Channel between the two. However, the fresh water diluting the South Wales coastal water contained about 11 $\mu g.$ atom/$L^{20}$ of phosphorus, almost all phosphate, whereas fresh water diluting the Wexford coastal water was not markedly different from the sea water. The two low salinity waters were definitely not connected.

All the analyses for this work have been made by Mr. F. A. J. ARMSTRONG.

COOPER, L. H. N. 1951. Chemical properties of the sea water in the neighbourhood of the Labadie Bank. *Journ. Mar. Biol. Assoc.*, vol. 30, pp. 21—26.

HARVEY, H. W. 1948. The estimation of phosphate and of total phosphorus in sea waters. *Journ. Mar. Biol. Assoc.*, vol. 27, pp. 337—359.

G 25

# Sea Density Observations near Bombay

By

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The location of Bombay and Alibag magnetic observatories has been near a sea coast where the tidal range is fairly large. To study the effect of the tides on the magnetic elements, it would be necessary to know the salinity of the sea which can be deduced from the sea-density observations. Further in the tropical Indian Ocean, it would be interesting to know the transport of sea-water from one latitude to another *e.g.* from the equatorial latitudes to higher ones and if this transport could be related to movement of air in the same region (See Proc. Ind. Sci. Congr. Patna, 1948, Part III, Abstracts (Physics) p. 176, No. 47 — Tropical Oceanography).

Daily observations were made at Colaba (Bombay) and at Alibag about 18 miles SSE of Bombay of the sea-density from May 1949. Check observations were also made by getting water from areas far away from the coast with the help of boatmen. On some days observations were made to determine the diurnal variation if any of the sea density. With the accuracy used, the diurnal variation could be considered negligible.

There was a considerable drop in the sea density in the monsoon months. The daily variations could be observed. To be able to understand the individual readings, instead of taking daily values five day running mean values were plotted. The mean rainfall at five stations in the neighbouring sea-level stations was also

plotted. From the trend of the two curves, it appears that the observations are consistent with the transport of sea-water from lower latitudes to higher ones at intervals during the S. W. monsoon in the Indian Ocean.

G 25.1

# On the Water Exchange through a narrow Channel connecting a Basin with fresh Water Inflow to the Sea

By

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Stockholm is situated at the inner end of a basin, the area of which is 110 km² and maximum depth 55 m. The basin is receiving an influx of fresh water from the lake Mälaren, rising to 40 million m³/day in the spring and coming down to 4 million m³/day in the summer. In the other end the basin is connected to the Baltic by a few narrow channels, only one of which, viz. the Oxdjupet, has a depth exceeding 4 m. Prior to 1919 the depth of the Oxdjupet was 8 m, in 1919 it was deepened to 10.5 m, in 1929 to 12 m, and in 1950 to 19 m. The enterprise in 1950 was induced by the necessity to increase the water exhange in order to get rid of the poisonous sewage products accumulating in the deeper parts of the basin. It was preceded by a hydrological investigation part of which was carried out by the present writer.

In the basin there is a surface layer with a low salinity separated by a thin boundary layer from the deep water, the salinity of which is slowly increasing with depth. As a rule there is a low-salinity surface current running out in the channel, and a salt under-current running in from the Baltic. Knowing the freshwater influx from the lake Mälaren and the density distribution in the vicinity of both ends of the channel, and assuming stationary conditions, it is possible to compute the water level difference between both ends of the channel and the amount of water

transported by both currents. The salt transportation in both directions being the same it is possible to compute the change in the water level difference brought about by a deepening of the channel and, further, the amount of water transported in both directions after a deepening of the channel. The computations have been verified by comparing the salinity changes in the surface layer of the basin brought about by the earlier deepenings of the channel with the computed salinity changes, a very good accordance being arrived at. Observations are carried out at present in order to verify the predictions as to the consequences of the deepening of the channel in 1950.

G 26

# Observations d'Echos sur la Mer avec le Radar du Musee Oceanographique de Monaco

Par

JULES ROUCH

Directeur du Musée Océanographique de Monaco

Le Musée Océanographique de Monaco utilise, depuis la fin de l'année 1950, un appareil radar fonctionnant sur la longueur d'onde de 3,2 centimètres. En dehors d'autres recherches, cet appareil est utilisé à observer les échos sur la mer. S'il n'est pas douteux, que ces échos ont bien pour origine la surface de la mer, ou peut être son voisinage immédiat, par contre il n'a pas été possible, jusqu'ici, de préciser de façon certaine la nature et la localisation des éléments matériels qui réfléchissent l'onde venue du radar.

En fait, le phénomène des échos sur la mer se manifeste, sur les écrans d'un radar, sous des aspects très variés et cette diversité reflète l'influence des nombreuses variables qui contribuent à le produire.

Les échos sur la mer ont déjà fait l'objet d'expériences et d'études théoriques, pendant et après la guerre, en Angleterre et aux U.S.A. Mais la durée de chacune de ces expériences a été très limitée dans le temps. Leurs résultats ont permis, cependant, de donner la préférence à certaines des hypothéses émises sur l'origine des réflexions observées. En particulier, il semble que le rôle joué par réflexion sur les gouttes d'embruns soit minime, ainsi que la part revenant à des réflexions sur des surfaces à peu près planes et normales à la direction du radar. Le rôle principal pourrait alors revenir à l'accumulation de toutes les réflexions diffuses sur les parties des vagues ayant les plus petits rayons de

courbures, c'est-à-dire les petites arêtes qui existent en très grand nombre et à peu près dans tous les stades de l'agitation de la mer.

Nos observations n'ont pas pour objet de résoudre des problèmes particuliers, en relation avec l'exploitation du radar dans telle ou telle circonstance. Elles visent, en premier lieu, à nous permettre de prendre une connaissance qualitative de cette grande variété d'aspect des échos de la mer, qui est précisément une de leurs caractéristiques les plus frappantes. Dans ce but nous avons fait des observations à peu près quotidiennes depuis le mois de Novembre 1950.

Nous avons été frappés par la différence d'aspect et de répartition spatiale que présentent les échos de la mer, d'une part lorsqu' il y a des vagues ou de la houle, et d'autre part lorsque la mer est calme.

Dans le premier cas, les échos de la mer sont répartis uniformément dans toutes les directions explorées par le radar, en présentant bien entendu, une décroissance rapide avec la distance. Les fluctuations des échos sont importantes mais l'enveloppe de leur maximum et sa décroissance avec la distance sont néanmoins bien définies, et, dans l'ensemble, leur aspect est très semblable à celui des fluctuations dues au bruit de fond du récepteur. La seule irrégularité que nous ayons constatée, dans ces conditions, et elle mérite qu'on essaye d'en découvrir la cause, consiste en une ligne d'échos plus intenses, orientée perpendiculairement à la direction de propagation des vagues et qui, chaque fois qu'on l'a observée, est demeurée stable pendant plusieurs heures.

Par mer calme, les échos sur la mer ont un aspect bien différent et beaucoup plus varié. Dans leur distribution spatiale, d'abord, ces échos se limitent, très souvent, à certaines zones de la surface, à l'exclusion d'autres zones ou il y a beaucoup moins, ou pas du tout, d'échos. Ces limites sont fréquemment de véritables discontinuités, qui, en général, nous ont paru correspondre sur la mer, à des lignes de séparation entre deux eaux de coloration différente ou dont l'état d'agitation superficielle n'était pas le même. Dans leur aspect, d'autre part, si ces échos ressemblent encore à du bruit de fond lorsqu'il existe à la surface de la mer un véritable clapotis, au contraire, lorsque la mer est vraiment calme les échos prennent de plus en plus l'aspect d'éclats isolés,

fugitifs mais souvent très intenses, et qui changent continuellement de position, dans les limites de la zone ou ils existent.

Ces échos n'ont donc plus le caractère d'une réflexion diffuse et on pourrait plutôt les attribuer à des lobes secondaires de réflexion de surfaces planes assez étendues.

Quant à la distribution par zones bien limitées, que nous avons fréquemment observée, elle pourrait être due à l'existence de pellicules superficielles. Celles-ci pourraient diminuer la réflexion soit par leur effet sur la tension superficielle, soit aussi, peut être, par l'effet de leurs caractéristiques électriques différentes. Ces phénomènes, lorsqu'ils auront été expliqués, permettront vraisemblablement d'employer le radar, en océanographie, pour donner des renseignements sur l'état physique de la couche superficielle de la mer.

G 27

# On the Transparency of Sea Water

By

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A difference of colour sensations between a Secchi's disc in the sea and the surrounding sea water is calculated according to the theory of E. SCHRODINGER. The investigations are made for a sea supposed filled with pure water as well as that with natural waters. The similar investigations are also performed for a disc in water viewed through a glass colour filter. The results of calculations are shown in the following tables.

Table 1. *The difference of colour sensations between the sea of pure water and a white disc in it.*

| | The depth at which a disc is immersed | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
| Diff. of colour ..... | 0.102 | 0.094 | 0.084 | 0.076 | 0.064 | 0.046 | 0.022 |
| Diff. of brightness .... | 1.999 | 1.526 | 1.166 | 0.864 | 0.640 | 0.461 | 0.329 |
| Diff. of total sensation | 2.001 | 1.530 | 1.169 | 0.867 | 0.643 | 0.463 | 0.330 |

Table 2. *The difference of colour sensations between the sea waters and a white disc at the dept where it is just visible.*

| | Bay of Tokyo | Lake Inawa-shiro | Lake Numa-zawa | Bay of Suruga |
|---|---|---|---|---|
| Depth just visible ..... | 1.7 | 8.7 | 11.6 | 12.0 |
| Diff. of colour ..... | 0.018 | 0.046 | 0.016 | 0.042 |
| Diff. of brightness ..... | 0.082 | 0.104 | 0.043 | 0.293 |
| Diff. of total sensation ..... | 0.084 | 0.113 | 0.047 | 0.295 |

Table 3. *The difference of colour sensations between the sea water and a white disc at the depth where it is just visible, viewed through colour filters.*

| Colour filter | | V-R3 | V-01 | V-G1 | V-B1 | V-V1 |
|---|---|---|---|---|---|---|
| Tristimulous coefficient of filter | red | 0.849 | 0.587 | 0.282 | 0.163 | 0.001 |
| | green | 0.151 | 0.405 | 0.468 | 0.315 | 0.008 |
| | violet | 0.000 | 0.008 | 0.250 | 0.522 | 0.991 |
| Lake Inswashiro | | | | | | |
| Depth just visible | | 6.12 | 7.88 | 7.70 | 7.38 | 6.46 |
| Diff. of colour | | 0.027 | 0.029 | 0.042 | 0.031 | 0.024 |
| Diff. of brightness | | 0.31 | 0.31 | 0.25 | 0.54 | 0.61 |
| Lake Numazawa | | | | | | |
| Depth just visible | | 10.3 | 11.0 | 10.5 | 10.3 | 5.5 |
| Diff. of colour | | 0.029 | 0.018 | 0.035 | 0.040 | 0.037 |
| Diff. of brightness | | 0.43 | 0.21 | 0.43 | 0.22 | 0.87 |

It is concluded that the difference in colour sensations reaches a definite value at the depth where the disc is just visible, although the difference of brightness is far greater than that of colour.

These phenomena are due to the flecked reflection of sky light at the wavy surface of the sea. Therefore, the author has considered that the colour of the disc is kept in view to measure the transparency of sea water by Secchi's disc.

G 28

# The Influence of the Enclosure of the Zuyderzee on the Hydrographic Conditions of the adjacent Sea-area

By

A. VOLKER

Engineer of the Zuyderzeeworks

At the Zuyderzeeworks two separate activities are to distinguish:

1 the enclosure of the former Zuyderzee to prevent the salt water of the North Sea from penetrating into the newly formed lake — the socalled IJssellake — behind the enclosing dam, and

2 the reclamation of new land in this freshwater lake.

The enclosing dam consists of a small dam between the province of North Holland and the island of Wieringen, and the main dam (completed in May 1932) between that island and the Frisian coast near Zurig. The main dam with a length of about 32 kilometers, encloses the IJssellake, nowadays with an area of about 3 020 square kilometers.

It was expected that changes in the tidal movement, the stormfloods and the system of channels in the adjacent Waddenzee would occur. The tidal movement would gradually change during the construction of the embankment. Therefore a clear insight into this question — the height of the subsequent stormfloods and the velocity of the currents in the last gaps of the enclosing dam being of great importance for the construction program — was necessary. It was not sufficient to have a qualitative insight into these questions; a quantitative one was also necessary. The investigation of this question was very complicated and difficult: a Royal Commission under the presidency of the well-known physicist and mathematician, the late Professor H. A. Lorentz, was in charge of it.

The Commission concluded that there would be an increase in

the tidal range outside the main dam of about 90 percent; the level of high water was expected to rise about as much as the low-water level would fall; and the storm-flood heights near the dam would increase by about 1,20 meter. The changes so far observed agree exactly with the conclusions.

There was also a prediction about the formation of a watershed ("wantide") between the two main entrances to the Waddenzee, viz. Marsdiep (near den Helder) and Vlie (between Vlieland and Terschelling), the forming of new channels and high flats between them. The latter has only commenced and it will take a very long time before equilibrium conditions are established; a shortage of one billion $m^3$ sand must be replenished and it is still a problem whence this sand must come.

The development has to be followed very care fully, the interests of navigation and the discharging capacity of the out-lets in the enclosing dam being endangered.

Salinity has decreased; the salinity of the Waddenzee is lowest near the out-lets in the enclosing dam where the fresh water of the IJssellake is evacuated.

## Supplément

Par

FRANCESCO VERCELLI

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Le problème des niveaux moyens de la mer a un intérêt tout spécial et mérite d'être étudié sous plusieurs point de vue.

Les Publ. Scient. No. 5 et No. 10 de notre Association ont permis de contrôler, d'une façon générale, que tous les océans, depuis trois quarts de siécle, augmentent de niveau dans la mesure de 1.5 mm par an; ce chiffre est dépassé dans les régions ou le sol est sujet à des mouvements géologiques d'affaissement; au contraire, il est atténué ou même changé de signe, sur les côtes qui se soulèvent.

L'élévation générale de la mer a une frappante corrélation

avec la débâcle des glaciers terrestres. L'eau qui s'écoule des glaciers augmente la masse des océans, et l'eau solidifiée sur les glaciers est enlevie à la mer. Apres l'expansion glaciaire vers 1860, on a eu de fortes retraites et de faibles avances, et enfin une débâcle progressive qui a prédominé jusqu'ici. Les glaciers fondent et la mer s'élève.

La phase actuelle des variations de niveau correspond probablement à la branche ascensionnelle d'une fluctuation séculaire et sera suivie par une phase descendante. Mais nous n'avons pas des séries d'observations suffisamment longues pour reconnaitre la durée et l'amplitude d'une telle fluctuation; par conséquent on ne peut pas prévoir si les mers continueront à s'élever avec le rythme redoutable de 15 cm par siècle, ou bien si l'inversion aura lieu bientôt.

Les deux phénomènes, débacle des glaciers, et élévation des mers, sont en rapport avec les conditions climatiques du globe et dépendent, en définitive, des cycles de l'activité solaire. C'est ce que l'on constate par l'analyse des courbes qui représentent les niveaux annuales de la mer. Dans ces courbes on observe des fluctuations tres variables, superposées a une ligne moyenne qui représente la dénivellation progressive. L'analyse periodique permet de décomposer les fluctuations dans la somme de sinusoides à ampleur variable, dont les périodes sont les mêmes que celles que l'on trouve dans les courbes solaires et climatiques, c'est á dire 11 ans, et les multiples et sous multiples de ce chiffre.

L'onde déclinationelle lunaire de 18,6 ans n'est appréciable que dans les mers où les marées diurnes sont bién développées.

Ces phénomènes soulèvent beaucoup de problèmes d'ordre scientifique et pratique.

Les zéros des nivellations de précision représentent les niveaux moyens de la mer pour une époque bien déterminée; ils sont donc des repères conventionels, proches des niveaux effectifs, qui peuvent en différer considérablement.

Les enregistrements marégraphiques doivent être continués sans limite de temps et dans des conditions de pleine homogénéité. Il faut avoir des séries séculaires d'observations pour qu'il soit possible de connaitre les rythmes des longues fluctuations et prévoir les variations des limites entre la terre et les eaux dans l'avenir.

G 29

# On the Change in the Height of the mean Sea-level in Japan

By

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The investigation on the variations in the heights of the mean sea-level at Aburatubo, Hososima, Wazima, and Osyoro, in Japan, during a period of 50 years, from 1900 to 1949, was made with the purposes of finding the relation between the occurrence of the great earthquakes and the conspicuous change in the height of the mean sea-level, and of increasing the reliability of the value of monthly mean sea-level as the standard of estimation for levelling, or for discussing, instead of levelling, on the vertical movement of the earth's crust.

After elimination of astronomical, oceanographic, and meteorological tides from the observed values of monthly mean sea-levels, to the first approximation, by taking the annual mean of observed value for 40 years, and further applying connections for the deviations of sea-water temperature and barometric pressure from the annual mean of secular years, we have arrived at the conclusion that the monthly mean sea-levels thus obtained, can be of some important practical use to tell the uplift and subsidence of the earth's crust or to be standards for levelling. Thus, we have found a fact that a minimum of the monthly mean sea-level, or a noticeable upheaval of the earth's crust appears during the month immediately preceding a great earthquake provided it occurs within 250 kilometres either in land or on the floor of the sea from the tidal station.

These results have already been reported in the Geographic Survey Institute Bulletin, Vol. I (1948), Vol. II (1950), Part I,

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